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8th lecture - Electricity

Notes on a Course of Lectures on Chemistry
delivered by Mr Brande in the Laboratory of the
Royal Institution in 1819.

The Analysis of bodies is produced by adding such substances as have greater attraction for its elements, than those elements have for each other, thereby destroying the attraction of aggregation by chemical affinity.

All substances consist in certain definite proportions.

Heat acts principally as a chemical agent, by its power of expanding bodies, or separating their elements to a greater distance from each other. Thus altering the state of bodies, as by changing solids, into fluids, & fluids into aeriform bodies. Thus ice is converted into water, & ether into gas by means of heat.

When bodies change their state, a considerable quantity of Heat disappears, or become latent.

All substances undergoing changes, either spontaneously, or by art, are subjects of chemical enquiry.

Of Combustible bodies, Supporters of Combustion, Those bodies which are neither combustible, nor supporters of combustion

The external forms of bodies often indicate their chemical qualities; for bodies of similar compositions, assume similar forms, & tho' calcareous Spar is found frequently assuming different shaped crystals, yet it is always capable of being resolved into one simple elementary one, in the shape of a Rhomboid.

1st Lecture.

On the general properties & chemical division of Matter.

The first class of Matter consists of Solids, the second of Fluids, the third of elastic fluids or Gases, & another of ethereal substances, as Light & Heat.

These various forms of matter depend upon active powers, such as Gravitation, Cohesion, Heat, chemical attraction, & Electricity.

There are about 50 simple or undecompounded bodies, 40 of which are metals

They are sometimes generally divided into Combustibles, & Supporters of Combustion, & Radiant or Metallic matter.

The Supporters of Combustion are

Oxygen
Chlorine
Iodine.

The combustibles bodies are Hydrogen, Sulphur, Phosphorus Boron ~~the Metals~~ Carbon, Azote, & the Metals.

But they are more properly divided into those that are separated at the positive surface & those that are separated at the negative surface of the Voltaic battery.

The negative bodies or those that are separated at the positive surface, are Oxygen, Chlorine, & Iodine

The others, or those that are separated at the Negative surface are Hydrogen, Azote, Sulphur, Phosphorus, Carbon and Boron.

All these are capable of combining with Oxygen, & all except Azote, with Chlorine, & in their electrical relations, as well as chemical powers, are opposed to Oxygen and Chlorine.

The three Powers which produce chemical changes are, Affinity, Heat, & Electricity.

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a knowledge of the different degrees of force in which bodies combine, constitutes the science of Chemistry.

If spirit of Wine be added to a solution of salt in water, the salt with reappear, on account of the greater attraction spirit has for water, than the water has for the salt.

If a piece of iron be dipped into a solution of copper dissolved in any acid, the iron will be covered with a thin pellicule of copper, because the acid having a greater affinity for the iron than it has for the copper, leaves his metal to unite with the iron, & copper is precipitated

*Electricity may be produced, by Friction, Induction, Contact, or by a change of state

attraction acting under particular circumstances, is the cause of crystallization. & it often takes place dissimularly on the same substances, as there are various different sort of crystals of flint & carbonate of lime &c, all perhaps differing in form tho the same as to their chemical qualities, this depends upon the different degrees of regularity with which they have been formed, or upon the circumstances under which it has taken place. when however bodies are slowly & regularly crystallized they always assume regular figures, bodies of the same composition invariably affecting the same form, thus is the mineralogist often able to judge of the properties of a Salt by its outward form, without the aid of the chemist

Salts are not usually seen perfectly crystallized in very regular forms; because in the Arts, they are only anxious to purify them, & would lose much time in forming regular crystals.

Common Salt if regularly & slowly crystallized assumes the shape of a cube; Carbonate of lime takes the shape of a romboid. Alum, that of an Octoedron

* Tho' the fact is well known the cause has never been satisfactorily ascertained. The experiment may be tried best with Glauber Salt.

Every crystal while forming, is endowed with a sort of polarity, that is they combine in particular directions

Lecture the 2d

On Crystallization.

Different salts are known from each other by the peculiar figure of their crystals, as each salt preserves in an peculiar form

When a certain portion of the water of solution is evaporated, & the remainder left in a proper temperature at rest, the salt will shoot into crystals.

In order to obtain large & perfect crystals, the evaporation must be conducted very slowly, like a thin pellicle forms on the surface, the liquor must be then taken from the fire & suffered to remain for some time at rest.

A crystal of the same salt thrown into the solution will much accelerate the crystallization, & indeed any other will substance thrown in will have much the same effect, as it forms a nucleus, round which the crystals will more readily & gradually collect on cooling.

The free access of air has considerable influence on this process, for if a saturated solution of any salt be hot into a useful boiling hot, & then excluded from air, it will cool without crystallizing, but if air be afterwards admitted, it will begin evidently to crystallize immediately.

It must not be supposed that all crystallization is owing to solution in water; for melted Sulphur always crystallizes on cooling, which is the case with many other substances that have endured a strong heat.

The crystallization of Salts is owing to the attraction of the different particles of the salt, uniting on cooling, & forming a chemical combination with a portion of the water in which they are dissolved.

When either by the diminution of the quantity of liquid, or the reduction of the temperature, the force of cohesion causes a separation of a portion of the salt; in almost all cases the parts which are separated form a regular arrangement, owing to the relation between their figure & reciprocal affinity.

Salts The particles of Salts have such an affinity or attraction for each other, that if two different solutions be mixed together, & afterwards suffered gradually to cool & set rest, each particle of each different salt, will be separated from the other, & form two different kind of crystals, each disposed of a form peculiar to the Salt of which it is formed; hence two different salts in solution may be easily seperated.*

Newton says "When a liquor saturated with a Salt is evaporated "to a pellicule, & sufficiently cooled, the salt falls in regular

Crystallization will not take place regularly in the dark, as the influence of light always makes the crystals more perfect. & we often observe when camphor has been long kept in bottles, the part that has risen in vapour, has been slowly crystallized & always on that side of the bottle next the light.

Snow is the vapour of water assuming the crystalline form.

It often happens that the attraction of ~~water~~ some salts for water is so strong, that when crystallized, it still retains a quantity of it, called the water of crystallization, which is the principal cause of its transparency; chemical means must be used to withdraw the water from the salt in this case, when it effloresces & loses its transparency.

& and as water dissolves different salts, with different facility they are easily seperated.

Thi observed that crystallized bodies affect one form in preference to another. The fluor spar of Derbyshire & common salt crystallizes in cubes. Nitre assumes the form of a six-sided prism, & Sulphate of magnesia that of a four-sided prism. but these forms are liable to vary, but in this case the crystals split in particular directions, & by splitting will assume their regular form, hence we may conclude that the internal structure of all crystals of the same body is alike, however the external shapes differ.

The Angles of Crystals are measured by an instrument called a Goniometer

Hence they are used whenever we want to absorb moisture, or to dry the air by absorbing its humidity.

It is well known to those who works on gems, that crystals can be mechanically divided only in certain directions, so as to afford smooth surfaces, & that if separated in any other way, the fracture instead of being polished like the other, is ragged & uneven.

"crystals, before being collected, the saline particles floated in
"the liquor equally distant from each other; they acted therefore
"mutually on each other, with a force which was equal at equal
"distances, & unequal at unequal distances; so in virtue of this
force they arrange themselves in an uniform manner."

The quantity of the water of crystallization varies very much in
different salts, for tho' some salts take up very little water,
other combine with more than their own weight.

Crystallized salts are liable to changes in their appearance
by exposure to atmospheric air; some salts deliquesce, &
other effloresce, so as to lose their crystalline form entirely
by such exposure.

Salts which deliquesce have so great an affinity for water,
that they absorb it with avidity from the atmosphere, & thereby
become moist or liquid.

Those that effloresce, having lost affinity for water
than atmospheric air has, lose their water of crystallization
by exposure, & readily fall into powder.

Lecture the 3d.

On Chemical attraction or affinity.

Chemical affinity is that which subsists between the particles of bodies, that are dissimilar.

Whenever the force of attraction operates between particles of the same species it is called the attraction of Cohesion, but when between the particles of different substances, it is called chemical affinity

all the operations of Chemistry are founded on the force of attraction, which nature has established between the particles of bodies, & by which forces all bodies cohere. the art of Chemistry employs different means to destroy this attraction of Cohesion, & to form fresh substances by the means of new attractions.

Chemical affinity can only exist between the particles of opposite & distinct substances, & this species of attraction is exerted with different force, according to the nature of such substances, & frequently in proportion to the mass. most bodies combine only in certain proportions, & the new combinations acquire new properties, & are incapable of separation by mechanical means.

The new chemical powers that bodies acquire in consequence of mixture & combination, are often extremely remarkable, & can only be learned by experiment. it frequently happens that inert bodies produce inert compounds, & that active substances remain active when combined; but the reverse often occurs. Thus oxygen, sulphur, & water, in themselves quite tasteless & condentively inert produce sulphuric acid, commonly called oil of Vitriol, when chemically combined; & Potash, which is a powerful caustic, when combined with sulphuric acid forms a salt possessed of little activity. the colour & specific gravity & temperature of bodies are also commonly altered by chemical action, thus a blue vegetable infusion in ~~water~~ water, is rendered red by acids, green by alkalies, & its colour destroyed by Chlorine. when equal parts of sulphuric acid & water are mixed, the resulting liquid has a specific gravity much above the mean, the volume is reduced & the temperature much increased, & ignition frequently attends chemical action.

As chemical action takes place among the ultimate or constituent elements of bodies, it must obviously be opposed by the cohesion of their particles, & chemical attraction is often prevented by mechanical aggregation. thus if a piece of the metal of antimony, be put into a gas called Chlorine, it is only slowly & superficially acted upon, but if reduced to powder, it rapidly unites with the gas, & burns the instant it is introduced.

Heat increases the chemical energies of bodies. its effects are generally referable to the diminution of adhesion by the expansion which it occasions. Different bodies are possessed of different attractive powers, & if mixed be brought together, those which have the strongest mutual affinities unite first into union; thus if Nitric acid be poured into a mixture of lime & magnesia in water, it dissolves the former in preference to the latter earth. this knowledge enables us to perform the process of decomposition. this is an instance of elective attraction.

This to be observed that in this change, that the substance produced has not any of the properties of its elements, but that it presents new characters, 2ly that much Heat & light is evolved during the mutual action, 3ly that they will unite in certain proportions only, & if any excess of either be present, it will remain uncombined, if there be too much Sulphur it will escape in vapour, if too much copper that excess will suffer no change.

In liquids & gases, similar changes of properties may be exhibited & in many cases, a change of form & state results. Thus the combination of aeriform bodies produces a solid, as when Muriatic & Ammoniacal ~~gases~~ gases are mixed together, producing the solid salt called Sal Ammoniac or Muriate of Ammonia. Solids also frequently produce liquids, as in the case of Iodide. & liquids produce gases, as when one part of Nitric acid is mixed with two of alcohol. & in some cases liquids mixed produce solids, their affinity for each other enabling them to separate a quantity of water which holds them in solution.

Thus the characters of bodies are always changing; but in some
Thus the characters of bodies are always changing; but in some cases this unequable circumstance does not exist, & the leading changes this unequable circumstance does not exist, & the leading characters of the bodies are still obvious. This is often remarked in the mixture of different gaseous bodies, & in solutions

As an instance of elective attraction, add a solution of the oxide of Zinc to a solution of Potash; the zinc will be precipitated, for the acid has a greater affinity to the Potash than it has for the zinc, so a solution of lime in water add carbonic acid, & the lime is precipitated.

As of Sulphate of Soda & Nitrate of Baryta in solution be mixed, both are decomposed, & Sulphate of Baryta, & Nitrate of Soda are produced.

Thus Sulphur & copper melted together form a substance totally different in quality to either of its constituent parts

Oxygen & Hydrogen combine only in one proportion & form water, a substance wholly dissimilar to either.

Salt Petre & Muriate of Ammonia & sulphate of Soda, both in crystals, be rubbed together in a mortar in equal proportions, the mixture will be converted into a fluid.

Various other instances may & will be adduced in the course of the lectures.

Chemical affinity is of three kinds, viz Simple affinity, compound affinity, & disposing affinity.

Simple affinity is when two ~~contrary~~ substances unite merely in consequence of their mutual attraction

Compound affinity is when two compound substances by their united action mutually decompose each other, & produce two or more new compounds.

When bodies which apparently have no tendency to unite of themselves, combine in consequence of the addition of another substance, the union is said to be produced by means of Disposing affinity.

In all compound gaseous bodies, the quantities of the elements are uniform for each species, & when two gaseous elements combine in more than one proportion, that the second & third proportion is always a multiple or a divisor of the first.

Chemical affinity may be pleasingly illustrated by the composition & decomposition of ink. If tincture of Galls ~~Sulphate~~ oxide of iron, be mixed, the mixture becomes black, from the affinity which the gallic acid has for the oxide of iron. if a little weak Nitrous acid be poured into it, the liquor becomes immediately transparent. this arises from the metal leaving the first acid to unite with the last, to which it has a greater affinity. but if a solution of Potash be now added, the Nitrous acid will quit the iron, & unite to the alkali; then the iron being once more disengaged, will again be caught by the gallic acid, & once more produce a black colour.

These two notes refer to text in the next page.

Glass is less expansible than any of the metals. # 100 parts of each at the freezing point of water becoming about 137·5 at the boiling point.

+ Currents are constantly produced in the ocean & in great bodies of water in consequence of this effect; ~~in~~

When bodies unite so as to form one compound only, that compound under whatever circumstances ever produced, whether by nature or art, always contains the same relative proportions of its components; & when two bodies unite in more than one proportion, the second, third &c proportions are multiples or divisions of the first

Thus water, as will be seen, is compound of Hydrogen & Oxygen, & one part by weight of the former gas unites to 8 of the latter. & in volume as 2 : 1.

& is thus represented

Water

Hyd	Oxy
1	8

Muriatic acid gas consists of one part by weight of Hydrogen, & 36 by weight of Chlorine, & the volumes are equal, as thus

Muriatic acid Gas.

Hy	Chlorin
1	36

Carbonic acid unites to Potash in two proportions, & forms two definite compounds, in the one 70 parts of Potash are combined with 30 of Carbonic acid; in the other 70 parts of Potash are united to 60 parts of Carbonic acid.

Lead combines with oxygen in three proportions; the first compound consist of 100 lead + 8 Oxygen, the second of 100 + 12, the third of 100 + 16.

Bodies are always obedient to these laws of union, & in whatever way are produced, their component parts exist in the same relative proportion. This observation applies to all cases of energetic chemical combination, but in some instances bodies may be said to unite in all proportions, as water & alcohol &c. other bodies combine in all proportions up to a certain point only, beyond which combination no longer ensues. Thus water takes up salt like it is saturated.

Its expansive power is not permanent but only temporary, as the heated body will contract again on cooling.

Thus the atoms of all substances are in continual motion, constantly enlarging & contracting at different temperatures.

Solids are the least expansible by heat, fluids more so, & gaseous bodies the most of all.

Each metal has a peculiar power of expansion. Platinum is the least expansible; Copper, Iron, Tin, Lead much more so

This causes inconvenience much in the construction of clocks & time-keepers in very hot or cold climates, causing a elongation or contraction of the pendulum; to remedy which gridiron pendulums, & balance wheels have been invented for keeping time more exactly on change of climate; the former are suspended by bars formed of different metals the latter made of two metals soldered together, by which means they counteract each other, & keep the time pieces at a more equable regulation.

Thin liquids are generally most expansible when hot at the lowest temperatures, & vice versâ, hence Mercury the best for Thermometers.

1 100 measures of air or vapour when heated from the freezing to the boiling point of water suffer an increase in bulk = 37.5 part at a near pressure. & very small degree of heat affect gaseous bodies considerably.

The expansion of liquids is not equable, for equal additions of heat at different temperatures. Thus the addition of 5° of heat to Alcohol at 40° will produce a less relative increase of bulk than the same addition of heat to alkohol of 100°

Lecture the. 4th

On Heat or Calorie

On the Expansive power of Heat.

One of the principal properties of heat is the power it has of expanding all bodies, & it acts diametrically opposite to the attraction of Cohesion.

The degree of expansion is not the same in all bodies

Thus water expands much more than mercury, alcohol more than water, & ether more than alcohol.

Metals have different degrees of expansion by heat

Aeriform bodies & vapor all expand ~~equally & in the same proportions~~ alike & when heated to the same degree. *

all the above bodies return again on cooling to their former dimensions.

The different Thermometers of air, water, Spirit, & mercury will prove the above facts.

If a polished cylinder of tin which accurately fits a ring, be heated so as to make water boil, it will no longer pass thro' the ring, & will be found enlarged in all its dimensions.

It is evident that the density of bodies must be diminished by expansion, & in the case of fluids & gases, the parts of which are mobile, many important phenomena + depend upon this circumstance; if heat be applied to fluids or to gases, the

heated parts change their place & rise, & the colder parts
descend & occupy their places.
In the Atmosphere heated air is constantly rising, & colder air
rushes in to supply its place; & this event is the principal
cause of winds
There are very few exceptions to the law of expansion of bodies by
heat, & these exceptions seem entirely to depend upon some
chemical change in the constitution of bodies, or their
crystalline arrangements
Thus clay contracts considerably by heat, but in this case the
clay first gives off water which was united with peach, & afterwards
these parts cohere together with more force
Water expands a little before it congeals, & expands considerably
during its conversion into ice, but in this case it assumes the
crystalline form, with parts which they are arranging themselves
in form regular solids, probably have greater intestices than
they occupied when at uniform distances in the fluid.
Water congeals only at the surface, where it is liable to the
action of the sun, & by warm currents of air which tend to
heat upon it to the fluid state, & when water approaches near the
freezing point, it begins to descend, so that no ice can form
till the whole of the water has been cooled to the point when
it has reached the greatest density + which is at 40 degrees.

The best means of keeping rooms at a proper temperature in cold weather, so as to prevent an agreeable heat throughout, is not by making large fires in the rooms, but by warming the current of cold air in the entrance apartments & passages.

When water is cooled by frost, the upper stratum becomes heavier & sinks to the bottom, hence warmer water comes to the surface, & a deep lake cannot be frozen without a very long continuance of frost, as all the water must rise in it turn, before any can be frozen. & in a long continued frost, the colder water is at the surface, & that below much warmer.

Heat is also always producing changes in the density or specific gravity of fluids, when there is freedom of motion among the particles. If I apply heat to the bottom of a vessel of water, the heated part expands & rises, like a cork or chosen stratum occupies its place. This may be very easily shewn by colouring the water at the bottom only, which when heated will be seen to rise thro' the mass.

In air similar currents are continually produced. The vibratory motion observed over chimney tops, & slated roofs which have been heated by the sun, depends upon this circumstance. The warm air rises, its repelling force being less than that of the circumambient cool air, the currents are rendered visible by the distortion of objects viewd thro' them.

That the force with which water expands in the act of freezing is very considerable, is shewn by the rupture of glass pipes in which this suffered to freeze.

The cause of expansion is this, that the force of cohesion is diminished by the interposition of heat between the particles of bodies: & also when equal quantities of heat are added in succession, the last portion meets with less resistance, & their expansive force & not the positive quantities of heat are added in succession, the last portion meets with less resistance, & their expansive force & not the positive quantities of heat are added equally with equal augments of both.

The expansive freezing water is accompanied by so great a force as not to be easily withstood.

When salt water freezes the salt is deposited at the bottom, the warmer the solutions the more salt it holds. hence frozen sea water is fresh & may be drunk.

This anomaly in respect to water is productive of very important consequences, in preserving the depths of frozen lakes of a temperature congenial to their inhabitants

Trees are often split from the freezing of water in their crevices, & rich banks crumble down from the effects of frost, from the same cause the the clods of ploughed land are broken to the great benefit of the farmer.

+ Therefore in all buildings intended to endure for a length of time, should be built of that kind of stone the least permeable to water.

Metals expand so much by heat, that in hot climates, the pendulums of clocks & springs of watches, no longer continue to mark the time with exactness, & various contrivances have been invented to counteract their effects

†The expansion of water during its conversion into ice, is shewn by the circumstance of ice swimming upon water; & if water in a deep vessel be examined at the time ice is forming, it will be found a little warmer at the bottom than at the top, these circumstances are of great importance in the economy of nature.

The mean density of water is at 40°, above & below which degree it always expands.

†The gradual decay of rocks is caused, by water getting into the crevices, when by expanding on freezing, it causes considerable pieces to be broken off.

The ratio of expansion by heat does not strictly keep pace with the actual increments of temperature, but the amount of expansion increases with the temperature.

⊗Consequently a striking exception to the general law of nature.

Lecture the 5th

On Heat

On the Thermometer, Temperature, & ~~Specific~~ Heat of Capacity.

When equal quantities of the same matter differently heated are mixed together, as much as the one contracts, so much the other seems to expand, & there will be no sensible change of volume.

If cold water at 50 & hot water at 100 be mixed together, the temperature of the mixture will always be 75 or a mean temperature.

It is on this idea, that when heat is communicated from body to body, as much is gained by one body, as is lost by the other that Thermometers have been framed, & the doctrines of temperature, & capacity for heat founded.

The most common Thermometer is a glass bulb, containing mercury, terminated by a glass tube, having a very narrow and equal bore. the mercury is boiled to expel any air or moisture that might be attached to it; & at the moment it is in ebullition, the extremity of the tube being drawn to a fine point is hermetically sealed by a spirit lamp. for the purpose of acquiring a scale, the bulb is first plunged into melting ice (which at that time has the same temperature as the ice itself) & the place where the mercury stands, is marked:

In dividing the scale of a Thermometer, the two fixed points always resorted to, are the freezing & boiling of water, which always takes place at the same temperature, when under the same atmospheric pressure. The intermediate part of the scale is divided into any convenient number of degrees, & this obvious fact all Thermometers thus constructed, will indicate the same degree of heat, when exposed to the same temperature

In the centigrade Thermometer this space is divided into 100, the freezing of water being marked 0°, the boiling point 100°. In this country we use Fahrenheit scale, of which the 0° is placed at 32° below the freezing of water, which therefore is marked 32°, & the boiling point 212°, the intermediate spaces being divided 180°. Another scale is Reaumur, the freezing point is 0°, the boiling point 80°.

Each degree of Fahrenheit' scale is equal to $\frac{4}{9}$ of a degree on Reaumur, & therefore the number of degrees on Fahrenheit scale, above or below the freezing of water be multiplied by 4, & divided by 9, the product will be the correspondent degree of Reaumur.

Thus Fahrenheit Reaumur.

$$68 - 32 = 36 \times 4 = 144 \div 9 = 16$$

$$212 - 32 = 180 \times 4 = 720 \div 9 = 80.$$

To reduce the degrees of Reaumur to those of Fahrenheit, they are to be multiplied by 9, & divided by 4.

Reaumur Fahrenheit

$$16 \times 9 = 144 \div 4 = 36 + 32 = 68$$

$$80 \times 9 = 720 \div 4 = 180 + 32 = 212$$

Every degree of Fahrenheit is equal to $\frac{5}{9}$ of a degree on the Centigrade scale; the reduction therefore is as follows.

Fahrenheit Centigrade

$$212 - 32 = 180 \times 5 = 900 \div 9 = 100°.$$

Centigrade

$$100 \times 9 = 900 \div 5 = 180 + 32 = 212°$$

In order to fill the thermometer with the liquid, first immerse it in it, & heat the bulb, when a portion of the air will be expelled from the tube, & the liquid will necessarily rise; repeat this process till the bulb be quite full, & all the air extracted.

Mercury is the best thermometrical liquid, because it is more equal in its expansion; when a high degree of heat without boiling, a very low degree without freezing. Spirit is good for measuring very low temperatures, as it never freezes, but not for high ones as it boils below boiling water, & enlarges very unequally as it approaches its boiling point.

Air thermometers are the most applicable for indicating very small degrees of temperatures.

In estimating temperature, our senses are extremely imperfect, for we compare our sensations of heat, not with any fixed or uniform standard, but with those sensations, of which we have had immediately previous experience. The same portion of water will feel warm to a hand just removed from contact with snow, & cold to another hand, which has been heated before the fire. To convey therefore any precise notion of temperature, we are obliged to describe the degree of expansion produced in some one body, which has been previously agreed upon as a standard of comparison. But the extremes of heat & cold have never yet been ascertained.

it is afterwards plunged into boiling water, & the same operation repeated.

On Fahrenheits thermometer, this space is divided into 180 equal parts, & similar parts taken above & below for extending the scale; & the freezing point of water is placed at 32°, & the boiling point at 212°.

180 degrees of Fahrenheit are equal to one degree of the Centigrade or French thermometer, & 2·25 to one degree of Reaumur.

This gives a good comparative scale for ascertaining different degrees of the temperature of liquor, as boiling water, & ice, have always respectively the same temperature under the same atmospheric pressure.

Other fluids besides mercury, such as alcohol, are sometimes used, particularly for measuring low degrees when mercury freezes, but it cannot be used for high degrees, because the conversion of the spirit into vapor would burst the instrument.

The air or differential thermometer is not only affected by changes of temperature, but by variations of atmospheric pressure; hence it is adopted to detect minute changes of temperature, which mercury would scarcely discover. it is affected only by the difference of heat in the corresponding balls, & is calculated to measure such difference with the greatest nicety

This instrument is peculiarly adapted to ascertain the difference of the temperatures of two contiguous spots of the same atmosphere, as for determining the heat in the foci of a reflector.

Metal thermometers have also been invented, upon the known principal of expansion of different metals.

Water cannot be used on account of its property of always expanding above or below 40°.

When equal volumes of different bodies of different temperatures are suffered to remain in contact till they are possessed of the same temperature, it is found that this temperature is not a mean one, as it would be in the case of equal volumes of the same body. This difference is said to depend upon the different capacities of bodies for heat

Thus mercury has a much less capacity for heat than water

If a pint of quicksilver at 100°, be mixed with a pint of water at 50° the resulting temperature will not be 75° but about 70°: the mercury has lost 30°, whereas the water has gained only 20°; or in other words a larger quantity of heat is required to raise the temperature of a pint of water than that of a pint of mercury, tho' the same number of degrees.°

In general those bodies are most slowly heated, & cool most slowly, which have the greatest capacities for heat; thus gases in general have greater capacities than fluids, & fluids than solids +

Tables of the relative capacities of bodies are given in the works of different authors.

o Or that the capacity of Mercury for heat is less than that of water

* Thus if equal quantities of water & quicksilver be placed at equal distances from the fire, the quicksilver will be more rapidly heated than the water, & the metal will cool most rapidly when carried to a cold place.

And bodies of the same temperature, or sensible heat, do not possess the same quantity of heat of capacity.

+ The increased capacity which air acquires by rarefaction has ch influence in modifying natural temperatures; thus the air, becoming rare as it ascends absorbs its own heat, whence becomes cold in proportion as it recedes from the earth's surface; thus moisture, rain or snow, are thrown down on the mountain tops.

In certain cases, caloric is absorbed by bodies, with a loss of its distinguishing properties, & it can then be no longer discovered by our senses or the thermometer, but becomes latent.

Heat, like all other bodies, may exist in two different states, in a state of freedom, when it easily discovered by our senses; or in a state of combination, when it becomes latent.

In one case it is called free caloric, or heat of temperature; in the other latent heat.

a And it is a general rule that all bodies, by an increase of density combine or give out heat which passes from a latent to a free state.

Solid bodies convey heat in all directions, & some much more quickly than others. it is chiefly owing to the different conducting powers of bodies, that they affect us when we touch them, with different sensations of cold. Thus if we coldly the hand in succession to a number of bodies; they appear cold in different degrees. & as this sensation is occasioned by the passage of heat out of the hand into the body which it touches; that body will feel the coldest, which carries away heat the most quickly, or is the best conductor. for the same reason, of two bodies which are both to the same degree, & both considerably above the hand, the best conductor is the hotter to the touch. Thus the money in our pockets often feels hotter than the clothes which contain them.

Lecture the 6th

On Heat continued

On conductors of Heat, & Latent Heat, & Caloric & Fluidity

Rarefaction of air produces considerable diminution of heat as may be observed by introducing the bulb of a thermometer into an exhausted receiver

Upon exhausting a receiver a slight appearance of vapour is often seen in the glass on the first stroke of the pump, occasioned by the air becoming rarified, consequently cooler, & no longer holding so much vapor in solution, it therefore becomes apparent on the glass. + a Condensation on the contrary produces much heat, as may be seen by the condensing pumps for setting fire to tinder.

In liquids, whenever a mixture occupies less space than all of the materials would seperately, a condensation of the liquid takes place, & in the case of a mixture of sulphuric acid & water a very great heat is given out.

Different bodies have their temperatures differently raised by the addition, or diminished by the subtraction of equal quantities of heat, & they are likewise very differently affected by heat These differences are said to depend upon the different powers of these bodies for conducting heat

Metals are of all bodies the best conductors of heat, but some of them are much better than others, thus Silver is the best &

lead the worst of the metallic conductors, except Platina.
Down, feathers, & other porous articles of clothing are bad conductors, & are therefore admirably fitted for protecting us from cold, & they inclose & retain air, which being a stile worse conductor, enhances the effect.

Water is a very bad conductor of heat, & is generally heated by a diffusion of its particles, by a change of place, from a change of specific gravity.

Air is also a bad conductor

Whenever we wish to confine heat, bad conductors must be used.

Therefore we wear woolen cloths; & the walls of furnaces are always lined with bad conductors; & in building an ice-house a stratum of air should be left to prevent heat entering from without.

As heat is propagated very slowly thro' gaseous bodies, so they communicate it very slowly to other bodies. The heat of metals at the temperature of 120 is scarcely supportable; water scalds at 150, but air may be heated to 240 without being painful to our organs of sensation

When solids are converted into fluids, or fluids into gasses, there is always a loss of heat of temperature, & vice versâ when gasses are converted into fluids, or fluids into solids, there is an increase

Liquid & aeriform bodies convey heat generally by an actual change in ~~the particles~~ the situation of their particles, that portion of the fluid, which is nearest to the source of heat, is expanded, becomes lighter, ascends, & is replaced by a colder portion from above

And it was once supposed that water could only convey heat in this manner, or that it was a perfect non-conductor, but experience has since proved, that water is a conductor of heat, tho' a very slow & imperfect one. If a piece of paper be wrapped closely round a brass rod, it will not readily burn, because the conducting power of the brass carries away the heat from the paper. but if wrapped round a wooden rod, it burns immediately, for wood being a bad conductor, the heat is also communicated to the paper.

It is on the principle of atmospheric air being a non-conductor of heat, that double windows preserve the warmth of apartments at an equable temperature. in like manner double lids for boilers, formed so as to hold a stratum of air, are found to be very effectual for preserving the heat of the liquor with a very small portion of fuel.

On this principle also it is that light spongy substances such as furs & down afford the warmest clothing. hence it is that the snow which covers the earth in winter, holds an abundance of atmospheric air within its interstices, to preserve the warmth of those inmates of vegetables it is destined to protect, from the effects of the frost.

Heat has great influence on the forms or states of bodies, when we heat a solid it becomes fluid or gaseous; & liquids are converted into aeriform bodies or vapours

During the liquefaction of bodies, a quantity of heat is absorbed, which is essential to the state of fluidity, & which does not increase the density or thermometrical temperature. Consequently if a cold solid body, & the same body hot & in a liquid state, be mixed in known proportions, the temperature after mixture will not be the proportional mean, as would be the case if both were liquid, but will fall short of it; much of the heat of the hotter body being consumed in rendering the colder one liquid before it produces any effect upon the its sensible temperature. vide Experiment opposite. ⊗

And the heat which thus disappears or becomes combined, is called latent heat, or caloric of fluidity.

⊗ So that the latent heat of water is 140°, that of steam at about 960° Thus sudden liquefaction always produces cold, & this is the cause of all freezing mixtures.

a Heat is to all surrounding bodies.

Water thrown upon quick lime becomes condensed or embodied in the lime & causes considerable heat from this condensation.

When solution of Glauber salt is made suddenly to crystallize, its temperature is also considerably augmented.

Thus it seems a general rule that Liquefaction produces cold & condensation produces heat

The mixture of Muriate of Lime & ice now produces the greatest degree of cold yet known.

of heat of temperature, & in this case it is said that latent heat is absorbed or given out.

Thus if equal weights of snow at 32° & of water at 172° be mixed together, the whole of the snow is melted, but the temperature of the mixture is found to be only 32°, so that 140° of heat are lost

If one part of steam at 212° be mixed with 6 part by weight of water at 62°, the whole of the steam will be condensed, & the temperature of the fluid will become that of boiling water at 212°, so that there is a great increase of the heat of temperature, & 900 degrees may be considered as taken from the steam, & as added to the water.

The phenomena of these changes may be referred to a simple general law of which Dr Black was the discoverer, namely, that "whenever a body changes its form, its relations to temperature "are likewise changed, either increased or diminished

Thus many mixtures, occasioned by the melting of various different salts produce intense cold, by absorbing the heat from surrounding bodies.

On the contrary liquids on becoming solid, evolve or give out caloric, or in other words produce heat, as is the case with mixtures of sulphuric acid & water.

Heat is also given out during the congelation of water & other constant emission of caloric from praying substances operates

favorably; further the severity of the frost is mitigated, &
its progress retarded; thus accounts for its often feeling warmer
after a great fall of snow. on the other hand if the return of
caloric to the frozen body of water were not equally slow
sudden inundations would be occasioned.

When aqueous vapor is condensed into fluid in the atmosphere
heat is produced, & the formation of rain, hail & snow tends to
mitigate the severity of the winter

In the summer evaporation is constantly tending to cool
the surface

By strong pressure, fluids even are made luminous, & when an
elastic fluid is compressed by mechanical means, its temperature
is always raised.

In the common language of chemistry, it may be said
that the <u>capacity</u> of elastic fluids is diminished by
<u>compression</u>, & enlarged by <u>rarefaction</u>.

Again to prove that the conversion of a liquid into vapour is always attended with a great loss of thermometric heat, or in other words, a great quantity of heat becomes latent during the formation of vapour; immerse a thermometer into an open vessel of water placed over a lamp; the water boils & the quicksilver rises to 212°, & altho' the source of heat remains, both the water, nor the steam acquire a higher temperature than 212°, the heat thus becomes latent, & is consumed in the formation of steam.

When liquids are heated they acquire the gaseous form & become invisible elastic fluids, possessed of the mechanical properties of air. They retain this form or state as long as their temperature remains sufficiently high, but resume the liquid form when cooled again.

Thus is the cause of mist or vapour appearing on the outward surface of glass bottles filled with cold water, when brought into a warm room. Different fluids pass into the aeriform state at different temperatures, or their boiling points are different; these are also much regulated by the density or pressure of the atmosphere. For diminish atmospheric pressure, we lower the boiling point. when the barometer is at 28 inches, water will boil at a lower temperature than when it is at 31 inches. under mean pressure it boils at 212° at the top of Mont Blanc Mr de Saussure found that it boiled at 187°. Mr Leslie in the vacuum of an air-pump fluids boil at temperatures very considerably below their ordinary boiling points.

To ascertain the absolute loss of thermometric heat in the case water becoming steam, Dr Black instituted the following experiments. he noted the time required to raise a certain quantity of water to its boiling point, he then kept up the same heat till the whole was evaporated, & marked the time consumed by the whole process; it was then computed how that heat would have risen, supposing the rise to have gone on above 212° in the same ratio as below it; as the temperature of steam was the same as that of the water, it was fairly inferred that all the heat above 212 was absorbed by the constituents of aqueous vapour

Lecture 7th

Heat the cause of Vapour; of Steam.

Every liquid when of the same degree of chemical purity, & under equal circumstances of atmospheric pressure, has one peculiar point of temperature, at which it invariably boils

Thus pure water always boils at 212°, alcohol at 176°, & ether at 98 of Fahrenheit, which may be proved by the thermometer Steam has exactly the same temperature as boiling water Yet water, placed on a fire, continues to receive heat, every abundantly, even when boiling hot, & as this heat is not appreciable by the thermometer, it must exist in the steam, or in a state of chemical union.

The boiling point of the same fluid varies under different degrees of atmospheric pressure; Thus water which has just ceased to boil, has its ebullition renewed, when placed under an exhausted receiver. Alcohol & ether treated in the same manner boil violently at the temperature of the atmosphere.

In general liquids boil in vacuo, with about 140° less heat than under a mean pressure of the atmosphere.

And liquids always boil at a less degree of heat on the top of high hills than in the plain, on account of the smaller degree of atmospheric pressure

If a florence flask about three fourths filled with water, be allowed

to boil briskly for a few minutes, & immediately on removing it from the lamp, be tightly corked up; the water will now cease to boil, but on cooling the flask with a wet cloth, the boiling will be renewed, owing to the formation of an imperfect vacuum over the hot water, by the condensation of the steam.

So that if the pressure of the atmosphere were removed, many bodies which at present have a liquid form, would cease to be such, & would be changed into a gaseous state

So that if we add to certain liquids a sufficient degree of heat, they are immediately converted into gases: or their temperatures remaining the same, if the weight of the atmosphere be diminished, the heat which they naturally contain exerts its tendency with equal effect, & they are in like manner converted into gases. These facts are easily shewn by experiments upon Ether[x].

By considerably increasing the atmospheric pressure, water may be heated to above 400°, without being changed into vapor.

~~Steam~~ Vapour is composed of heat & water, & the latent heat of Steam is at between 900° & 1000°.

The process of evaporation absorbs heat & produces cold[a].

For if a thermometer be moistened with spirits of wine or ether & exposed to the air, & and successive times, the mercury will sink at each exposure, because the volatile liquor, during

When steam is condensed, or when vapours resume the liquid state, their latent heat becomes sensible, & in this way it is obvious, that a small quantity of steam will during its condensation, communicate heat sufficient to make boil a large quantity of water.

* If Ether be poured upon the bulb of a Thermometer, or any quick evaporator, will make the mercury sink very considerably, showing that cold has been produced.

If Ether be poured into a small thin flask immersed in water, & placed under the receiver of an air pump in which a good vacuum can be formed, the Ether will boil & the water freeze. But if the evaporation of the ether causes cold sufficient to freeze the water.

Water by conversion into steam has its bulk prodigiously enlarged. a cubic inch of water occupies, when converted into steam, the space of about a cubic foot.

evaporation, robs it of its heat, & this experiment if made in a thin glass with water instead of mercury, will sometimes create a sufficient degree of cold, to freeze the water.

On the contrary vapours during their conversion into a liquid form give out much heat.

Thus cold water may be made to boil, by causing steam to be introduced into it by means of pipes.

The heat given out by the condensation of steam is rendered apparent by the following experiment

Thro' 8 ounces of water at 51° contained in a glass jar, steam was passed from the boiler, till the temperature of the water in the jar rose to 177°; on weighing the water, it was found to have gained 9 drachms; that is precisely 9 drachms of steam had been condensed, & had imparted its heat to the water

In the foregoing experiment, 9 drachms of steam at 212°, added to 64 drachms of water at 51°, produced 73 drachms of water at 177°

Now 73 · 177 = 12921 = whole heat of the mixture

64 · 51 = 3264 = heat of 64 dr., one of the two component parts

Difference = 9657 = heat of 9 dr. the other component part.

Therefore 9657 divided by 9 = 1073° should have been the temperature of the latter portion (viz 9 drachms) had none of its heat been latent. and 1073 − 212 = 861° gives the latent heat of the steam

Mr Watts however from more accurate experiments determines the latent heat of steam to be from 950 to 1000°

In hot dry weather it is obvious that there must be much more vapour in the atmosphere than in cold wet weather; & it appears to be the aqueous vapour in the atmosphere, which, when condensed by the mixture of cold with hot air, or by other agencies occasioning a change of temperature, is the cause of dew, rain, & ultimately of springs & rivers.

When aqueous vapour is condensed into fluid in the atmosphere heat is produced; & the formation of rain, hail & snow tends to mitigate the severity of the winter: in the summer on the contrary evaporation is constantly tending to cool the surface.

The vessels generally used for cooling water &c are made of very porous earthenware filled with water, & as a small quantity is perpetually oozing thro' every part of the vessel, a constant evaporation from the outside is kept up.

In India the rooms are left open on all sides, the roof being supported on pillars, & the intervals hung with curtains: servants without doors scatter water on these curtains continually, & its evaporation makes the rooms cool.

* They will first be attracted. The Key have imbibed a certain quantity of electricity, & then they will be repelled, the Key have touched some conductor, which carries it off; after which they will be again attracted & repelled as before.

The rubber & the glass are both electrified, & if two pith balls be electrified by touching either the glass or the silk they repel each other, because they are similarly electrified; but if one ball be electrified by the glass & the other by the silk they will attract each other, shewing that they are dissimilarly electrified, or that the glass & the silk are electrified the one positively the other negatively.

When glass is rubbed with silk, a portion of electricity leaves the silk & enters the glass. it becomes positive therefore & the silk negative. but when sealing wax or sulphur is rubbed with flannel, the wax loses & the flannel gains; the former therefore is negative the latter positive

All bodies in nature are then regarded as containing the electric fluid & when its equilibrium is disturbed, they exhibit the phaenomena which have been described

Lecture the 8th.

on Electricity.

If a piece of dry silk be briskly rubbed against glass, it will be found to have acquired the property of adhering to it; & they will both be found to have gained the property of attracting very light substances.

These bodies are said to be electrically excited, & the phenomena which they exhibit are best observed by the use of the electrical machine.

Many bodies are capable of exhibiting electrical phenomena, but they were first observed in vitreous & resinous bodies, which appear to be possessed of opposite electrical attractions, & are called vitreous & resinous, or positive & negative Electricity.

All substances similarly electrified repel each other, but when dissimilarly electrified attract each other.

And electrified bodies that repel each other, are considered as in the same electrical states; those that attract each other, as in different electrical states.

A pith ball that has been electrified by glass, will be repelled by a ball electrified by resin or sulphur, & these attraction and repellent states depend entirely upon the action of the two substances, & not upon any power peculiar to, or inherent in each.

It is upon this circumstance that the electrometer is framed: when any electrified body is made to touch the upper plate

the gold leaves diverge; if their divergence is increased by the approach of glass excited by silk, they are said to have the same state as the glass, the others or the positive; if their divergence is diminished, they are said to be in the opposite state, or to possess the resinous or negative electricity.°

Bodies receive the electrical influence in different manners. If a rod of glass be brought in contact with any excited body it will receive the electrical influence in the part where it touched the body, & will become electrical to a little distance only, but its remote parts will not be effected.

A rod of metal on the contrary, when electrified in the same manner, will instantly become electrical throughout.

The glass is said to be a non-conductor or insulating substance the metal a conductor.

Animal & vegetable substances, water & fluids are said to be imperfect conductors.°

It appears that in all cases of electrical action, the two electrical states are always equal, & capable of neutralizing each other. If a connection be made by a wire between the positive and negative conductors, all electrical effects cease.

When a thin plate of any nonconducting substance placed upon a conductor, is brought in contact with an excited body; the surface opposite to that in contact, gains the opposite electricity from that of the excited body, & the plate is found to possess two surfaces

To find the kind of Electricity by which the leaves are charged may be judged of by approaching the cap of the instrument with a stick of sealing wax; if it be negative, the divergence will increase; if positive the leaves will collapse, upon the principle of the mutual annihilation of the opposite electricities.

Electricity is accumulated only upon the surface of bodies, as a hollow conductor, will contain as much electricity as a solid one, provided their surfaces are equal.

When an electrical machine is at work, the rubber is deprived of its natural share of electricity or rendered negative, & the conductor is rendered positive by having more electricity conveyed into it, than it had in its natural state.

There are many minute substances which show signs of electricity when heated, as the Tourmaline, Topaz & diamond, & these bodies the different surfaces exhibit different electric states.

× Damp air is also a conductor of Electricity, consequently machines always act best in dry frosty weather, & will act but very feebly if the glass & apparatus be not perfectly dry clean & warm, & if they be not so, the moisture will carry off the electricity as soon as formed. Condensed air will tend to prevent the escape of Electricity, but rarefied air will cause it to escape, & if a charged vial be inclosed in an exhausted receiver of an air pump, on removing it, its electricity will be gone.

Among liquids those only are conductors of Electricity which contain Oxygen as one of their elements.

The use of the metallic coatings of the Leyden vial is equally to distribute the electricity, over the opposite surfaces, & to render the discharge more simultaneous by the conducting coating suffering the transfer of the opposite electricities from every part of the glass surfaces at the same time.

in opposite states.

If a conductor be brought into the neighbourhood of an excited body, the air, which is a non-conductor, being between them, that extremity of the conductor which is opposite to the excited body, gains the opposite electricity, as this is found by examining the electricity of gilt balls raised on wires at the different ends of the conductor, which are then effected by what is called Induction.

If instead of air a plate of glass be between the two conductors, the same phenomena will occur, so that it would appear that the conductor merely gains two opposite electricities, or holes electricities of the same kind of those of the non-conductor. The phenomena of sparks, discharges, & of accumulated electricity depend upon this law.

In the case of the common electrical spark, a stratum of air is charged in the same manner, as the Leyden jar; when the hand is held near the positive conductor, the person standing on the ground, the hand is rendered negative, & the states become exalted, like the polarities as they are called, are annihilated when the air, producing a spark.

If a number of small pith balls placed upon the surface of metal, are caused to approach an electrified body, they are brought into the opposite state by Induction, & are attracted towards the body, but when they come in contact with it, this state is destroyed. They gain the same state & are repelled, when the attraction & repulsions may be produced as

long as the machine is in action.

If a number of cylinders of metal insulated on glass be placed in a line with each other, but not in contact, & the last be connected with the ground, when an electrified conductor is brought opposite to the first, they will all become electrical, & every insulated cylinder will present two Poles, the negative pole of one being opposite to the positive pole of the other, & if a spark is produced by means of the last, sparks occur throughout the whole arrangement.

In like manner series of Leyden jars may be made to charge each other, the outer surface of the first rendering negative the inner surface of the second, & so on, & by connecting the surfaces that have the same kind of electricity, in the first place, & then connecting two opposite surfaces in the series a powerful explosion may be produced.

Induction therefore is the cause of Polarity, & when the positive & negative electricity unite a spark or detonation takes place, & the electricity ceases, by the equilibrium being restored.

all that is effected by the action of an electrifying machine is a distribution of the natural quantity of Electricity in bodies, or a transfer of it from some to others, in consequence of which the latter acquire a redundance, or are positively electrified; the former become proportionally deficient in their natural quantity of Electricity, and are therefore negatively electrified.

† Electricians employ the term Quantity to indicate the absolute quantity of electric power in any body; & the term Intensity to signify its power of passing thro' a certain stratum of air, or other ille conducting medium.

Lecture the 9th Same Subject continued.

On the Quantity & Intensity of Electricity; of Lightening, & of the Voltaic apparatus.

Large surfaces are electrified by induction much more slowly than small ones, & are capable of accumulating much more electricity, which renders the discharge from them much more violent.

Indeed the electrical powers seem entirely to belong to the surfaces of bodies, not to be connected with the quantity of solid matter they contain.

If a large Leyden jar & a small one be charged with the same quantity of electricity, the spark from the former will not be so long as a spark taken from the other would be

Hence it is said a shorter & more feeble spark is drawn from a larger surface, & its Intensity is less, tho' the Quantity is not altered in this case.+

Yet tho' large surfaces diminish the Intensity, they can be made to accumulate & increase the Quantity

When very small conducting surfaces are used for conveying very large quantities of electricity they become ignited, & of the different conductors that have been compared, charcoal is most easily heated by electrical discharges.

Certain changes in the forms of bodies are always connected with electrical effects, thus when vapour is formed or condensed,

the bodies in contact with the vapour become electrical. & they will be found by the Electrometer to be negatively electrified.

Sulphur when melted becomes electrical during congelation

Many of the important phenomina in nature depend upon this operation of electricity, from the evaporation that is constantly going on.

When aqueous vapour is condensed, the clouds formed are usually more or less electrical, & the earth below them being brought by induction into an opposite state, a discharge takes place when the clouds approach within a certain distance, constituting lightning, & the undulation of the air produced by the discharge, is the cause of thunder.

The water-spout is likewise probably the result of the operation of a weakly electrified cloud, at an inconsiderable elevation above the sea, brought into an opposite state: & the attraction of the lower part of the cloud for the surface of the water may be the immediate result of this phenomenon.

Electricity is also excited by the contact of metals.

If Zinc & copper be brought in contact with each other they will form an electrical combination, of which the zinc will be positive, & the copper negative, as may be proved

When an insulated plate of Zinc is brought into contact with one of silver or copper, it is found, after removed, to be positively electrical, while silver or copper is left in the opposite state

If the nerve of a recently killed frog be attached to a silver knife, & piece of Zinc be brought into the contact of the muscular fibres of the animal, convulsions are produced every time the metals thus connected are made to touch each other; exactly the same effect is produced by an electric spark.

If a piece of zinc be placed on the tongue, & a piece of silver under it, a peculiar sensation will be perceived every time the two metals are made to touch.

In these cases the chemical properties of the metals are observed to be effected; for if a silver & a zinc wire, be put into a wine glass full of dilute sulphuric acid, the zinc wire only will evolve gas; but upon bringing the two wires in contact, the silver will also copiously produce air bubbles.

If a number of alternations be made of copper silver leaf, zinc leaf, & thin paper, the electricity excited by the contact of the metals, will be rendered evident to the common electrometer. it will be found that the zinc end will be positively, & the silver or copper end negatively electrified; thus shewing that a polarity exists.

Mercury agitated in a glass bottle produces electricity, filings of zinc rubbed thro a silver sieve cause the same effect.

⊖ This fact explains why in the sheathing of ships, it is necessary to use both of the same metal which forms the plates; for if two different metals be employed, they both oxidate & rust very speedily, in consequence of their forming, with the water of the ocean, a simple galvanic circle.

Also for the same reason large bolts or any other metal instruments fastened together with nails, the nails should always be of the same metal with the material thro' which they are driven, to prevent them from speedily rusting.

by the electrometer.
and by increasing the power by a series of metallic plates of fluids
(called the Voltaic pile) & connecting the two ~~two~~ metals,
(which must be in contact with each other) with the nerve
& muscle in the limb of a frog; at the moment the contact is
completed, violent contraction of the limb will be occasioned.
If a piece of zinc & copper in contact with each other in one
point, be placed in contact in other points with the same
portion of water, the zinc will corrode & attract oxygene
from the water, much more rapidly than if it had not been
in contact with the copper; & if a small quantity of
sulphuric acid be added, it will be seen that globules
of inflammable air are given off from the copper, tho it is
not dissolved or acted upon.
When one hand is applied to the bottom of the pile, & the other
to the top, both hands being moistened a shock will be felt.
If a metallic wire having a bit of wide burnt charcoal
at its extremity, is made to connect the two extremities of
the pile, a spark will be perceived, & the point of the charcoal
will become ignited.
And it may be shewn by the Electrometer that the two
wires are diametrically electrified, that connected with the
zinc being positive, & the copper negative, whereas a

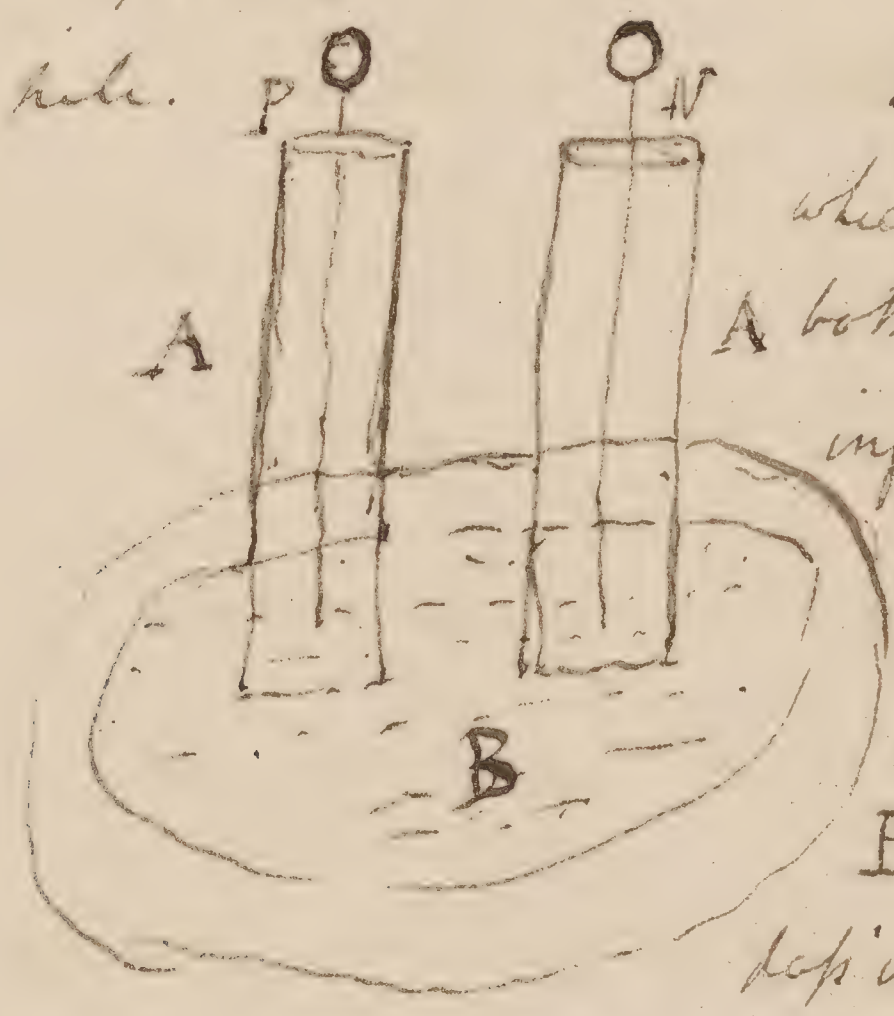
wire from the middle of the pile will not be effected.

If had been supposed that the effects of Magnetism, Galvanism & Electricity, were from different unknown causes, but it is now pretty well understood, that the three are only different modifications of Electricity.

In the Voltaic pile, the metals having the strongest attraction for Oxygene, are the metals which form the positive pole, in all cases in which the fluid menstrua act chemically by affording oxygene

Similar polar electrical arrangements to those formed by zinc & copper, may be made by various alternations of conducting & imperfect conducting substances, but for the accumulation of the power the series must consist of three substances or more, & one at least must be a conductor.

When bodies are thus under the influence of electrical decomposition. their usual chemical energies are suspended, & some very curious phenomena are obtained which may be illustrated by the following experiment; & even the compounds of acids & alkalies which posses a great affinity for each other, are separated by the galvanic fluid.



Fill the two glass tubes AA, which are closed at top & open at bottom with a blue vegetable infusion; & invert them in the basin B containing a solution of glauber salt (Sulphate of Soda) P & N are platinum wires, which dip into the tubes nearly to the bottom. & which are to be connected with the positive & negative extremities of the Voltaic apparatus; it will be found that oxygen is evolved at the wire P, & hydrogen at N, derived from the decomposition of the water, the Glauber salt (Sulphate of Soda) will also be decomposed; & the blue liquor will be rendered red in the positive vessel, by the accumulation of the acid, & green in the negative by the alkali, the salt being decomposed & the acid & the alkali forming it, will pass each other into the separate vessels without meeting, in consequence of being under the influence of electrical attraction.

Lecture the 15th

Description of Voltaic apparatus continued, & its Effects.

In the Voltaic apparatus the most oxidizable plate is always positive, the least oxidizable is always negative

Combustible bodies are attracted by the negative pole, & supporters of combustion, such as oxygene & chlorine are attracted by the positive pole.

Hence water is readily decomposed into its elements (Oxygene & Hydrogene)

If wires of Platina from the extremities of the pile be introduced into water, oxygene gas will seperate at the wire exhibiting the positive electricity, & hydrogene gas at the wire exhibiting the negative electricity, & the proportions are such, that they will produce water when exploded by the electrical spark, that is the volume of hydrogen will be to that of oxygene as two to one:

If the same wires be introduced into a strong solution of metallic salts, oxygene will separate at the positive surface, the inflammable or metallic matter contained in the solutions at the negative surface.

When any solution of a neutral salt containing acid, united to alkaline, earthy or common metallic matter is used, besides the other phenomena which takes place, acid matter collects round the positively electrified surface; alkali, earth, or oxyde round the negative surface ✕

Thus alkaline matter is attracted by the negative pole, & acid matter by the positive.

Hence Sulphate of Baryte, so difficult of decomposition by other means, may be easily decomposed by the Voltaic pile.

Muriatic acid is composed of hydrogene & chlorine, & a solution of that acid in water, be acted upon by the wires, hydrogene will separate at the negative surface, & chlorine or oxymuriatic gas at the positive surface.

Acids which are negative with respect to alkalies, metals & earths are separated from these bodies in the Voltaic circuit at the positive surface; & alkalies, metals & earths are separated from acids at the negative surface: & such are the attracting powers of these surfaces, that acids are transferred thro' alkaline solutions, & alkalies thro' acid solutions to the surfaces where they have their points of attraction, notwithstanding the powerful attraction of these bodies for each other, & as these bodies pass without combining, the electrical power of the Voltaic pile destroys their chemical power of combination.

Most of the substances that act distantly upon each other electrically are bodies such as act chemically, when their particles have freedom of motion: this is the case with the different metals, with sulphur & the metals, with acid & alkaline substances; the electrical power being in all cases apparently connected with the power of chemical combination*

5 The most difficultly decomposable compounds may be thus resolved into their component parts by the electrical agency; by a weak power the proximate elements are separated, & by a stronger power these are resolved into their ultimate constituents.

All bodies that combine chemically, so far as they have hitherto been examined, have been found to possess opposite states of electricity. Thus copper & zinc are in opposite states to each other, so are gold & mercury, sulphur & metals, acids & alkalies. By bringing two bodies into the same electrical state, which were before capable of union, we destroy their tendency to combination. Thus iron & zinc when negatively electrified, will not unite with oxygen.

* All bodies which exert powerful chemical agencies upon each other when freedom of motion is given to their particles, render each other oppositely electrical when acting as masses. Hence Sir H Davy has supposed that electrical & chemical phenomena, tho' in themselves quite distinct, may be dependent upon one & the same power, acting in the former case upon masses of matter, & in the other upon its particles.

Bodies that exhibit electrical effects however by their chemical action on each other, lose this power during combination

Thus if a polished plate of zinc is made to touch a surface of dry mercury, & quickly separated, it is found positively electrical; & the effect is increased by heat: but if it be heated to as to amalgamate, it no longer exhibits any mark of electricity.

Rarefied air is to some extent a conductor of electricity; when the communication between the points is made in rarefied air, the distance at which the discharge takes place, increases as the exhaustion is made

Such is the decomposing powers of electricity, that not even insoluble compounds are capable of resisting their energy; for even glass, sulphate of Baryta, fluor spar &c when submitted to the power of Voltaic me, are slowly acted upon, & the alkaline, earthy or acid matter carried to the poles in the common order.

Not even the most solid aggregates, nor the firmest compounds are capable of resisting this mode of attack; its operation is slow, but the results are certain; & sooner or later, by means of it, bodies are resolved into simples forms of matter.

Almost all the metals are burnt by the effects of the Voltaic pile, & create a most beautiful & brilliant flame.

Zinc being the most combustible of the metals is most easily burnt, & silver burns with a green flame.

It appears ~~by experiment~~ the intensity of voltaic electricity is the same in both cases ~~increased by the number of plates~~; but that the quantity is in some ratio as the surface.

The quantity in small plates is as much or more than such imperfect conductors as water & the human body can carry off by a small surface in contact; whilst better conductors can transmit the whole quantity afforded by larger plates even when used in very thin wires. the water & the animal substance discharges the electricity of a surface, probably not superior to that in contact with the metals. the wires discharge all the electricity of the plates.

Lecture the 11th

Same Subject continued.

It appears that when a quantity of Electricity is wanted, large surfaces are used with best effect.
But when we wish to produce Intensity we increase the number of alternate plates.

The energy of Combination to give repulsive or attractive powers to masses of matter or to effect the Electrometer, seems to increase with the number of series, as does the power to give shocks, & to decompose bodies; but as long as the surface of the gold leaves in the Electrometer, or of the human body, or of the water acted upon, is the same, & less than that of the acting plates, increase of surface of the plates is connected with no increase of power in the operation upon metallic substances or charcoal, or whose good imperfect conductors, the case however is different.

Thus tho' a battery compond of plates of copper & zinc a foot square, will not effect the condensing Electrometer more, nor decompose more water, nor give greater shocks to the fingers than a battery containing plates of an inch square; yet it will fuse a battery containing plates of an inch square; yet it will ignite more than 100 times as much fine platinum wire, and decompose sulphuric acid, & the water in strong saline solutions with infinitely more rapidity ⊗ vide opposite Page.

a battery constructed by Mr Children consisted of 20 double plates four feet by two, of which the whole surfaces were exposed to the action of diluted acid. this battery when in full action, had

no more effect on water, or on the human body than one containing an equal number of small plates; but when the circuit was made thro' metallic wires, the phænomena were of the most brilliant kind.

The most powerful combination that exists in which number of alternations is combined with extent of surface is in the Laboratory of the royal institution, in which the whole number of double plates is 2000, & the whole surface 120,000 square inches. this battery affords a series of brilliant & impressive effects. Platinum is melted by it as readily as wax, quartz & stone entend into fusion, & fragments of diamond seemed to evaporate by its effects.

The general facts of the connection of the increase of the different powers of a battery with the increase of the number & surface of the series are very distinct: but to determine the exact ratio is not easily to be resolved.

To produce great effects diluted acids must be introduced between the plates, & the strength of the Electricity is in direct ratio to the strength of the acid employed.

The shock of the Torpedo & electrical eel resemble the Voltaic shock, & the powers resides in organs which consist of a number of similar alternations of different substances. the effects are analogous to those which a Voltaic apparatus of small surface consisting of very numerous, but not very powerful series, would produce.

The power of the voltaic apparatus to communicate divergence to the Electrometer, is most obtained when it is constituted & filled with pure water; but its power of producing ignition & of giving shocks & of producing the other effects observed when its poles are connected are much altered by the interposition of acids, which act chemically upon one of the plates: here the insulation is interfered with by the production of the acid vapour which carries off a part of the electricity, but the quantity of Electricity is much increased, owing to the increase of the position energy of the most oxidizable metal by the contact & action of the acid.

These relative effects of quantity & intensity were shewn by Mr Children who constructed a battery the plates of which were two feet eight inches wide & six feet high; the effects upon metallic wires & perfect conductors were extremely intense; but upon imperfect conductors such as the human body & water, they were feeble.

With regard to the great speculative opinions & questions whether the electrical phenomena depend upon one fluid, in excess in the bodies positively electrified, & in deficiency in the bodies negatively electrified; or upon two different fluids, capable by their combination of producing heat & light; or whether they may be particular exertions of the general attractive powers of matter, it is perhaps impossible to decide in the present imperfect state of our knowledge.

However modern Chemists seem to incline to the latter opinion

The effects of Electricity are well known, & its application as an instrument of chemical decomposition, may be carried on independent of any hypothetical ideas concerning its causes.

Lecture the 12th

Of the general Properties of Light, & radiant Heat.

The laws of light belong more particularly to Optics, but as its effects are often chemically exerted, some of its principal properties should be described.

Some suppose Light to proceed from the undulation of a rare medium with which space is filled, others suppose it to emanate more immediately from the sun, & it about eight minutes in passing from the sun to the earth.

The rays of light in their transmission thro' bodies, or reflection from their surfaces, undergo certain modifications of great importance in their connection with the laws of vision, & the general properties of radiant matter.

If a rays of light pass from one transparent substance not crystallized into another in an oblique direction, their path is altered, & they are bent downwards or upwards, according as the medium is more or less dense

The rays of light in passing thro' obliquangular crystallized bodies, follow different laws. if a ray of light be received perpendicularly upon a plain surface of island crystal, one part of it passes thro' without altering its direction; another part on the contrary is refracted in a plane parallel to the diagonal, joining the two obtuse angles of the crystal,

The image formed by the different rays, separated by the prism, constitutes the solar spectrum, which supposing it to be divided into 300 parts; the red will occupy 45 of these parts, the orange 27, the yellow 48, the green 60 the indigo 40, & the violet 80

Heat & Light are not present, in corresponding degrees, in different parts of the solar spectrum. with respect to the illuminating power of each colour, the red rays, tho' the hottest, are far from illuminating in any exact degree. the orange possess more of it than the red, & the yellow rays illuminate objects still more perfectly; the maximum of illumination lies in the brightest yellow or palest green. the violet is very different.

The heating powers of the rays follow a different order. the red rays the most, & the violet the least, indeed scarce any at all.

so that images seen thro' the crystal appear double; & this is called the phenomina of <u>double refraction</u>.

When light is reflected from bodies, under most circumstances it is unaltered in its relations to the refractive powers of transparent substances, & the angle of reflection is equal to the angle of incidence.

When a ray of light is made to pass thro' a triangular prism of glass, & the transmitted light is received upon a sheet of white paper, it is found to be of different colours, viz red, orange, yellow, green, blue, indigo & violet

The red rays are the least refracted, the violet rays the most, & the other coloured rays are refracted intermediately, in the order in which they have been named.

If the differently coloured rays separated by the prism, be received upon one spot by means of lenses, they produce white light; & Newton has explained the different colours of bodies, by supposing that they retain certain of the coloured rays of light & reflect others. Thus red bodies are supposed to reflect red light, & to absorb all the other colours.

When similar thermometers are placed in the different parts of the solar beam, separated by the prism, it is found that different effects are produced in the differently coloured rays. The greatest heat is exhibited in the red rays, the least in the violet rays; & in a space beyond the red rays, where there is no visible light,

the increase of temperature is greatest of all.
These invisible heat-making rays may be reflected by the mirror
& refracted by the lens, exactly in the same manner as the rays of
light.
If a large concave mirror be placed on the ground & the hot
body be raised some feet above it, a thermometer will instantly
rise in the focus of the mirror, tho' it is evident that no current
of hot air can here downwards from the body.
This effect is called the radiation of heat. it is best observed by
employing two mirrors parallel to each other; if a small piece of
red hot charcoal be placed in the focus of the upper mirror, it
will cause phosphorus to inflame in the focus of the lower
mirror.
If the flame of a candle be placed in the focus of one mirror,
a heating effect in the other focus is obtained from the other; but if a plate
of glass be now interposed between the two mirrors, the rays of heat
are arrested, while those of light passing thro' the glass, are
collected as usual, in the opposite focus. This proves a
difference, between solar & terrestrial heat; the rays in the former pass
thro' glass without heating it, the rays of the latter are stopped by glass (it
becomes hot when exposed to them. + consequently deoxydizes it.

It has been long known, in regard to solar rays, that their heating effect depends much upon the colour of the surfaces upon which they impinge; that black & dark bodies are more heated than those which are white or of light tints, circumstances dependant upon absorbtion & reflection.

Those surfaces which are the best radiators of heat, are also gifted with the greatest absorbing powers. unmetallic & unpolished surfaces are the best radiators, & also the best receivers of radiant heat; while polished metallic surfaces are the worst radiators, & have the lowest absorbing powers.

In Professor Leslie's experiments it was found that a clean metallic surface produced an effect = 12 upon the thermometer. when covered with a thin coat of glue, its radiating powers was so far increased as to produce an effect = 80, & on covering it with lamp-black, it became = 100.

In these cases of radiation the colour of the surface does not interfere, the different effects must be referred to the mechanical structure of the radiating surface. White paper & lamp-black produce nearly the same effects, & broken coloured blue, red, yellow & green, does not differ in radiating power from that which is white; hence the colour produces no change of texture in the surface.

x) In the prismatic spectrum there three sets of rays are imperfectly separated, & arranged according to their refraction irrangibilities. The heating rays (the red) are the least refrangible, the coloriferous rays are supposed of more refrangibility, & the decomposing, or as some have called them, the deoxidizing rays (the violet) are the most refrangible.

Lecture the 13th

Chemical effects of Light, & Radiant Heat.

+ Heat & Light are not present, in corresponding degrees, in different parts of the solar spectrum. for generally speaking, those rays illuminate most, that have the least heating power. the rays in the center of the spectrum have the greatest illuminating power, as may be ascertained by viewing successively in each, a small body, such as the head of a common nail. We have already seen the heating power of the rays follow a different order, viz that the red rays produce the most heat, & that the heat is greatest of all just without the confines of the red ray.

But beyond the confines of the spectrum on the other side, viz a little beyond the violet ray, the thermometer is not effected; but in this place it is remarkable, that there are invisible rays of a different kind which exert all the chemical effects of the rays of light with greater energy.

Hence it appears that the solar beams consist of three distinct kinds of rays, of those that excite heat, & promote oxydation; of illuminating rays, & of deoxydizing rays

For one of the chief chemical properties of light is that it speedily changes from white to black, the most precipitated muriate of silver. this effect is produced most rapidly by the direct light of the sun, & the separated rays have this property in various degrees: the blue rays, for example effect a change in 15 seconds, which the red rays 20 minutes to accomplish; & generally speaking the more refrangible rays

as we recede from the violet extremity.

Light seems to be the cause of colour in plants, for when kept in the dark, they turn white; it is likewise necessary to their growth & vigor, as all plants will grow most on the side to which light is admitted.

A striking illustration of the different powers of the various rays of light is furnished, by their effect on phosphorus: in the rays beyond the red extremity it becomes heated, smokes, & emits white fumes, but these are presently suppressed on exposing it to the deoxydizing rays, which lie beyond the violet extremity.

Some gaseous bodies when mixed & exposed to light, are caused to combine chemically. *

Some bodies have the property of absorbing the rays of light, & of retaining them for some time, such are called phosphorescent bodies, or solar phosphori.

Others which do not otherwise give out light, evolve it, when heated. But these phenomena are independent of every thing like combustion for these bodies shine in the dark, when placed in the vacuum of an air-pump, or under water where no air can be present.

The manner in which the temperatures of bodies are effected by rays producing heat is different for different substances. The bodies that absorb most light, & of course reflect least, are most heated when exposed to the heating rays of light.

Thus black bodies in general are more heated than red; red more

* Thus equal quantities of hydrogen & chlorine when exposed to light for a short time, combine, & form muriatic acid gas, if exposed to the direct rays of the sun, the combination is very rapid, & often accompanied by an explosion.

Chlorine & carbonic acid have scarcely any tendency to combine even at high temperatures, when light is excluded; but exposed to the solar rays they enter into chemical union

than green; green more than yellow; yellow more than white.

Bodies that have their temperatures most easily raised by the action of heating rays, are likewise those that are most easily cooled by their own radiation, or that at the same temperature emit most heat-making rays.

Vessels that are intended to retain heat, should be metallic & highly polished, for the best radiators are the best absorbers.

Steam or hot air pipes for warming houses should be polished in those parts where the heat is not required to be communicated, & covered with some radiant substance such as lamp-black or plumbago in those rooms which are to be heated by them.

Culinary implements should be blackened & not polished on those parts which are to receive heat, because black has the greatest receptive power for heat.

There are about 61 elementary substances, the greater part of which are the metals.

By elementary we do not mean that that they are absolutely not decomposable, but only that hitherto no powers of chemistry have been able to effect this.

+ It may be connected with the electrical energies of bodies; for all bodies which powerfully act upon each other, as in the opposite electrical states of positive & negative, & the evolution of heat & light may depend upon the annihilation of these opposite states which happens whenever they combine.

+ Sulphur & ~~iron~~ Copper filings when heated together in an exhausted retort, produce much light & heat, even though that oxygen is not always necessary to combustion.

Nor is a combustible body always required for this purpose, as Euchlorine, (a compound of Oxygen & Chlorine) (both supporters of combustion, but neither of them is themselves combustible) with esculoda violently with light & heat, when only gently heated.

Lecture 14th.

On Oxygene & Chlorine, & cause of Combustion.

All cases of vivid chemical union are connected with the increase of temperature of the acting bodies, & a great radiation of heat from them, & in many instances light is also produced.

The old system of Stahl for accounting for Combustion, had long since given way to that of Lavoisier, & this last is now found insufficient for accounting for many phenomena, & all the latter researches seem to shew that no peculiar substance or form of matter is necessary for the effect; that it is a general result of the actions of any substances possessed of strong chemical attraction, or + of any substances possessed of different electrical relations, & that it takes place in all cases in which an intense & violent motion can be conceived to be communicated to the corpuscules of bodies.

Formerly it was supposed that Oxygene was the cause of all kind of combustion, but it has been since found that many bodies which have not been decompounded, & which cannot well be conceived to contain Oxygene, produce heat & light by their mutual chemical action. *

Matter is generally divided into Supporters of Combustion, and Combustible bodies.

The former likewise are distinguished by their acidifying principles, & when their compounds are submitted to electrical decomposition,

they are attracted by the positive poles, whereas all the other known undecompounded substances are seperated at the negative surface.

Only five of these clsps of bodies have been discovered. viz

Oxygene, Chlorine, Iodine, Fluorine & Bromine

Oxygene is procured from Manganese, red lead, & salt-petre, but is most pure when procured from Chlorate of Potassa.

Oxygene gas is distinguished from all other gaseous bodies by very important properties.

All inflammable substances burn in it with great vividness and wonderful brilliancy, & metal wires may be burned in it, if previously ignited.

If a taper the flame of which has been extinguished, the wick only remaining ignited, be plunged into this gas, it will be immediately rekindled.

It is likewise a great supporter of Respiration as well as of Combustion. Any small animal confined in jar of this gas lives four or five times as long as in an equal quantity of common air, it is therefore called vital air.

It is quite colourless, & very slightly soluble in water.

Its specific gravity is to that of Hydrogene as 16 is to 1; 100 cubical inches of it weighs about 33.88 grains. its specific gravity to air is 1.127

This gas forms a most important part of our atmosphere, as will be hereafter seen. it forms about $\frac{1}{5}$ of our Atmosphere.

In all instances of Combustion in the atmosphere, Oxygene is either fixed in the combustible body, or it dissolves it, or forms a new

There are six acidifiable combustible substances, namely Hydrogen, Nitrogen, Carbon, Sulphur, Phosphorus, & Boron; all of which are Electro-positive, or attracted to the negative pole of the Voltaic ~~Apparatus~~

There is no simple liquid, & the simple gaseous bodies are ~~short~~ four in number.

†For all common purposes it is most cheaply procured from the oxide of Manganese, but in all cases of delicate chemical enquiry it should be procured from the Chlorate of Potash, which affords it most pure.

+And these compounds are always either Oxides or Acids.

Thus most of the metals when burnt in Oxygen become Oxides, but Sulphur, Phosphorus, & Carbon acquire acid qualities.

The metals combine with Oxygen in certain fixed proportions thus take iron for instance. it is found that iron to become the Protoxide combines in this proportion, at the rate of 52 of iron to 15 of Oxygen. therefore if I have 12 grains of iron burnt in oxygen gas, & I wish to know how much oxygen it has combined with I say

Iron Oxy Iron
52 : 15 :: 12 : $x = 3'46$ grains of Oxygen.

$$52 \overline{)\,150\,(3'46}$$
$$\underline{156}$$
$$240$$
$$\underline{208}$$
$$320$$
$$\underline{312}$$
$$8$$

If Chlorine be agitated with water, it is absorbed by it & gives the water a yellowish colour, & becomes a solution of Chlorine, which has the property of destroying colours or changing them to a pale yellow. this may be tried with infusion of Litmus.

+When a receiver filled with this gas, not artificially dried, is surrounded by snow & pounded ice, the gas forms on the inner surface a solid concretion. by a moderate increase of heat, this crust melts into an oily liquid, which on a further elevation of temperature, passes to the state of gas.

+To make a good bleaching liquid, you may either agitate chlorine with water, or put a little red lead into a little water & pour a small quantity of Muriatic acid into it.

compound with it. +

During every combustion in this gas, it suffers a material diminution, because it becomes partly fixed in the combustible, which acquires thereby an additional weight.

Of Chlorine.

Chlorine is procured from Manganese, common salt, & sulphuric acid; & water; the best proportions are 8 parts of salt, 3 of manganese, 4 of water & 5 of acid. it may also be procured from oxyde of manganese & muriatic acid.

It is called chlorine from its yellowish green colour; its odour is very disagreable & hurtful to respiration.

Its specific gravity is to that of hydrogena nearly as 35 to 1. & 100 cubical inches of it weighs about 76.25 grains, at a mean temperature & pressure of the atmosphere. its specific gravity as to air is 2.52

It is absorbable to a certain extent by water, cold water dissolves about double it volume, & acquires a strong acrid taste & disagreable smell. warm water does not dissolve it so much, it may therefore be collected, for any immediate purpose, over it.

Many of the metals introduced into it in thin leaves or powder, take fire, & burn spontaneously at common temperatures; such are copper, tin arsenic, zinc, antimony & the alkaline metals.

This gas is not changed by any action of heat or cold, but its aqueous solution proves more readily than water. +

As metals burn in this gas, which has not been proved to contain oxygene, it proves the insufficiency of Lavoisiers system for accounting for the causes of Combustion.

This gas dissolved in water speedily destroys + all vegetable colours, which are rendered white, or brought to a dull yellow; & this

last tint is almost the only one not changed by the combined action of water & Chlorine. O

when however this gas is freed from vapour & perfectly dry, it does not act upon dry vegetable substances; water therefore must be present to effect the change.

This property of Chlorine is much used in bleaching. O

Chlorine is not so eminently a supporte of combustion as Oxygene, when an inflamed taper is introduced into it, the light continues; but of a dull red colour, & a dark carbonaceous smoke arises from the flame. S × only however in this instance, as metals burn in it spontaneously

⊕ Oxygene is a constituent part of water as well as of atmospheric air.

Its compounds are called Oxides, those of Chlorine are called Chlorides.

Oxygen readily enters into combination, & no substance is now eachin as a chemical agent. it is known to be a constituent part of most acids & earths, & of all the alkalis except one

The name of Oxygene was formerly given to it, as it was supposed to be the only acidifying principle, but later experiments have proved this to be erroneous, for tho' most acids contain Oxygene, yet Sulphuretted Hydrogen tho' possessed of acid qualities, certainly does not contain it; besides which it has lately been discovered that the alkalies & earths, are metallic bases united to Oxygen, therefore the name of Oxygene is now very improperly given to it. Sulphuric & Muriatic acids contain no Oxigen.

o In its ordinary state, if not heroically freed from moisture, it destroys vegetable colours, when being mixed with water. which may be shown by keping into it, a piece of paper stained with litmus, the colour of which will immediately disappear.

s The matter thrown off is the Carbon from the candle, with which Chlorine is incapable of combining, but if hydrogen is ~~in a manner that~~ be introduced into it, it burns vividly spontaneously & a Chloride of Phosphorus is produced.

If copper leaf be put into a retort, which is afterwards exhausted of air, (care should be taken to throw a cloth over it for fear the pressure of the air should burst it) & Chlorine be then admitted, the metal will burn immediately with considerable evolution of light & heat, the compound produced is a Chloride of Copper.

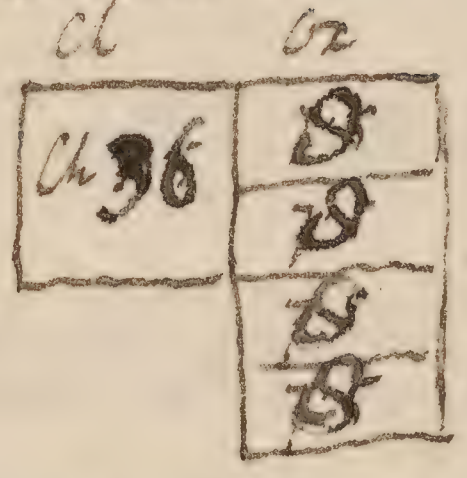
The Chlorine may be collected, it cannot be long preserved over water, as it would be soon absorbed; it should therefore be kept in bottles with ground glass stoppers. & care should be taken that no water be left in the bottle.

When a solution of Chlorine in water is exposed to the direct rays of the sun, oxygen gas is obtained, & the acid passes to the state of Muriatic acid. In this case the water is decomposed, its Hydrogen passes to the Chlorine to form the acid & the Oxygen is evolved.

Chlorine has a great affinity for many of the metals & will sometimes even deprive oxygen from them.

It has been supposed that Chlorine destroyed colours by parting with its oxygen, but late experiments have shown that it is a simple substance & contains no oxygen. It is now known that the oxygen is derived from the water, which is decomposed by double affinity, that of Hydrogen for Chlorine, & of the colouring matter for oxygen.

+ This is thus represented



The Number thereof is 68.

But these three Volumes condense into two, but when decomposed by heat the gas expands into the three volumes, so that the expansion is about one third. when heated it yellow colour disappears.

To shew this, without danger, let a small quantity of Euchlorine be collected in a small glass tube placed over mercury; if it be only warmed the tube will be driven out to a considerable distance.

Lecture 15th.

Of the Compounds of Oxygen & Chlorine. or Euchlorine. of Iodine, & of Hydrogen.

Chlorine & Oxygene are capable of existing in combination, & they form a peculiar gaseous matter. they do not unite when merely mixed together, but when existing in certain solids, they may be detached in union.

To make the compound of Chlorine & Oxygene, a small quantity of Chlorate of Potassa (formerly called hyperoxymuriate of Potassa) is introduced into a small retort of glass, & twice as much muriatic or sulphuric acid diluted with an equal volume of water. by the application of a gentle heat the gas is evolved, & as water absorbs it very quickly, it must be collected over mercury, & begins to form about the temperature of 150°.

It is called Euchlorine from its bright yellow-green colour, & more lively than that of Chlorine, its smell is pungent & not suffocable.

It is soluble in water, to which it gives a lemon-colour; water takes up 8 or 10 times its volume.

Its specific gravity is to that of hydrogene as nearly as 33 to 1. 100 cubical inches weigh between 74 & 75 grains. its specific gravity as to air is 2.36

It must be collected & examined with great care, & only in small quantities at a time, as a very gentle heat will sometimes cause it to explode; & it elements seperate from each other with great violence.

The elements of this gas hold together with a very trifling attraction, & it is decomposed with so much facility that it is not easy to ascertain

the action of combustibles upon it.

None of the metals that burn in chlorine, act upon this gas at common temperatures; but when the oxygene is seperated from it, it is converted into Chlorine, & the metals immediately burn. Let a little dutch foil be introduced into a small retort filled with Euchlorine, it will undergo no change, & will not even tarnish; but if the oxygene be detached, by any means, (either by applying heat, or passing up a little nitrous gas) Chlorine will remain behind, & at the same moment the foil will inflame, & burn with great brilliancy.

This phenomenon proves the fallacy of Lavoisier's system of combustion who maintains that combustion cannot take place without the presence of oxygene, whereas in this case it is caused by removing the Oxygene.

It is composed of 1 part in volume of Chlorine & 2 parts of Oxygene.

That the gas is actually composed of these elements, is shown by causing it to detonate in a small glass tube over pure mercury. it then loses its brilliant colour & becomes Chlorine & Oxygene & expands very considerably, in almost all other cases of invisible combustion there is a condensation of the bodies which unite; but in the decomposition of Euchlorine by heat, we have the first in the decomposition of an explosion, accompanied with remarkable phenomenon of an explosion, accompanied with heat & light, & an expansion of the elements which are separated from each other.

+ Thus Chlorine Oxy. $36 + 32 = 68$ the representation number. But these two volumes of Oxygen & one of Chlorine are in the gas condensed into two volumes.

Chloric Acid

Chlorine	Oxy
33·5	7·5
	7·5
	7·5
	7·5
	7·5

one Volume of Chlorine & ~~two~~ & a half of Oxygen.
Its Number Thereupon is 71

Perchloric Acid is composed of one Volume of Chlorine & 3½ volumes of Oxygen. Its number thereupon is 86.

+Iodine has a bluish black colour; its lustre is metallic; its specific gravity is 4·946; it is extremely volatile, & at a temperature between 60 & 80° produces a beautiful violet vapour, at a higher temperature it rises more rapidly, & on cooling condenses in brilliant crystals. Iodine is the best test for Starch & vice versâ. Whereon doves a beautiful blue precipitate.

+Iodine combines with Chlorine, forming the Chloriodic acid, which is easily obtained by the direct union of Chlorine upon Iodine; they unite & form crystals of a deep orange color

Euchlorine is called the Protoxyde of Chlorine

Chlorie acid is another compound of Chlorine with oxygen, & the Perchloric acid is a compound with a further addition of Oxygen.

Of Iodine.

Iodine is the third of the electro-negative substances.

It was discovered in 1812, & is procured from kelp or barilla.

Iodine at the ordinary temperature of the atmosphere resembles scales, or crystals of micaceous iron ore; its colour is bluish black; its lustre metallic; it is a nonconductor of electricity, & disposes in a high degree the electrical properties of oxygen & chlorine, being always determined to the positive pole of the galvanic apparatus.

It is volatizable by heat into a vapour of a most beautiful violet colour, whence its name of Iodine.

Its compounds with Oxygen are the Iodic & Iodinic acid, bodies of very little consequence.

Of Hydrogen.

The bodies to be considered among the number of electro-positive substances are six. viz Hydrogen, Azote, sulphur, Phosphorus, carbon, & boron.

All these substances are capable of combining with oxygen & all except Azote & charcoal with chlorine. They are separated in their combinations at the negative pole, & in their electrical relations, as well as chemical powers, are opposed to oxygen, chlorine & iodine.

Hydrogen is distinguished from all other bodies by its extreme lightness, & is procured from the decomposition of water (of which

it forms one of the elements.)

100 cubical inches of this gas at a mean temperature & pressure, weigh about 2 grains ¼ a quarter†. The number expressing it is unity. It is neither respirable nor a supporter of combustion, tho' itself highly inflammable.

If mixed with common air, or oxygen gas it explodes violently, by the action of an inflamed body or an electric spark.

Hydrogen is the body which gives the power of burning with flame to all the substances used for the economical purposes of heat & light.

⊛ It is rarely however that Oxygene & Hydrogene gases can be had in such a state of purity, as to have absolutely no admixture. To find the purity of Oxygene, let us suppose 100 measures of Oxy: are detonated with 300 of Hyd: & that they are reduced to 130, the diminution will be 270; this divided by 3 gives 90 for the quantity of the the Oxygene; that is the Oxygene employed must have contained 10 per cent of some foreign gas not condensible by Hydr.

⊕ If two parts of Oxygene be employed & two of hydrogene, one part of Oxygene will remain; in whatever proportions they are mixed together, it is found, that one of oxygene always condenses two of Hydrogene. it is evident then, that oxygene & hydrogene combine only in definite proportions, & that the water resulting is always the same in its constitution.

† Its specific gravity to that of air is 0·0748.

If tubes of glass be inverted over a small flame of Hydrogen gas, mixed with an equal, or even more than its own bulk of Oxygen, but little sound or explosion takes place. Hence we learn that all inflammable gases however pure in themselves, when they proceed from the combustion of the Hydrogen in burning with the oxygen of the air, cause a continual vibration in the air thus producing the sound.

o For ascertaining the purity of Hydrogen vide over leaf.

In a strong bottle or inflammable air bottle, mix equal parts of common air & hydrogen gas; on applying an electrical spark, the mixture will burn not silently (as it would if hydrogen alone were present) but with a sudden loud explosion; & this is occasioned by the oxygen of the common air. if the experiment be repeated with oxygen gas (instead of common air) in due proportion, the report will be considerably louder, & water will be the result, & the gases will disappear.

The purity of these gases may be discovered, by the knowledge of the proportion in which they combine. Thus to determine the purity of Hydrogen gas we mix it with more oxygen than is sufficient for saturation. Suppose that to 100 measures of hydrogen gas we add 100 of Oxygen, & suppose that 80 measures remain after detonation. the diminution will here be 120 measures, & of these two 3ds or 80 measures are hydrogen. hence the inflammable gas, under examination, must contain 20 per cent of some other gas, which is most probably nitrogen. for ascertaining the purity of Oxygen, vide one page back.

It has been discovered by Mr Bishop that a mixture of Hyd & nitr gases may be made to explode by mechanical compression.

Ans 100 cubical inches of hydrogen gas, the barometer being 30 inches, & the thermometer 60° weighs 2.25 grains.

Lecture 16th.

On the Compounds of Hydrogen with Oxygen, & Chlorine.

Hydrogen gas combines with oxygene gas, & this circumstance
in inflammation in the air is owing.
If the two gases be pure, water is the only result, & the proportions
are 2 of hydrogene & 16 of oxygene in weight, or as the numbers
expressing hydrogene is 1, that of oxygene is 8. or 2 & 1 in
volume.
That the union of the bases of these two gases form water may
be proved both by synthesis, & analysis.
If oxygene & hydrogene gases mixed in the proper proportion of
1 to 2, be exploded in a tube by the electrical spark, water
equal in weight to the two gases consumed, will be the result,
& the gases will entirely disappear, & if this experiment be
conducted over water, it will rise in the tube proving that all
air has disappeared.
The heat caused by the inflammation of these gases is very
intense, & may be used to fuse bodies intractable by any other
process.
To prove the composition of water by analysis, it may be separated
into 2 of hydrogen & 1 of oxygene in volume in the voltaic circuit.
the oxygene appears at the positive, the hydrogene at the negative
metallic surfaces; & by means of platina wires, hermetically

sealed into glass tubes, the products are collected. +

Some of the metals have the power of decomposing water into its two elements

Thus Potassium thrown into water, instantly inflames, and decomposes it, by absorbing the oxygene; & hydrogene gas is evolved, while the oxygen unites with the metal.

Other metals act more slowly upon it, & at higher temperatures.

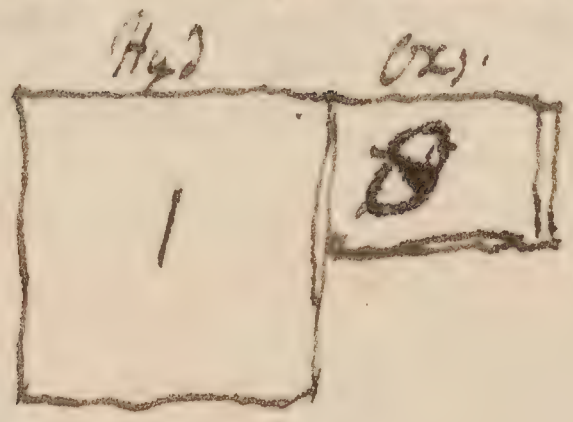
Procure a gun barrel, the breech of which has been removed, so as to form a tube open at both ends: file this with iron-wire coiled up in a spiral form. to one end of the barrel adapt a small glass retort, nearly filled with water, & to the other a bent glass tube, the open end of which terminates under the shelf of the pneumatic cistern; let the barrel be placed in a furnace; & when it is red hot, & the water be made to pass over it, it will be decomposed; its oxygen will unite with the iron; & its hydrogen will be obtained in the form of gas

Leaves of plants will also decompose water; for if a few green leaves be inclosed in an inverted glass under water exposed to the rays of the sun, bubbles of air will soon begin to form on the leaves, & will at last rise to the top of the vessel. in this experiment the hydrogene combines with

+ In the glass containing the positive wire one volume of Oxygen will be collected, & in the negative glass two volumes of hydrogen.

§ This method will prove the same analytically, for the weight of the hydrogen will be just equal to the weight of the oxygen combined with the metal, which will be just equal to the weight of the water consumed.

Water is then represented



Its Number is 9.

100 Cubic inches of pure water weigh 252·95 grains.

*This may be done by boiling it, or putting it under an exhausted receiver of an air pump.

The Specific gravity of ice as to water is from 94 to 97 to 100.

Water enters into combination with various solid bodies, & entirely loses its fluid form, & the compounds are called Hydrates.

100 Cubical inches of Hydrogen weigh 2·118 grains.

Hydrogen is to water as 1 : 1·943 and to air as 1 : 44·4

- 3 -

+ Chlorine unites with Hydrogen either silently or with detonation, according as the experiment is conducted.

+ About 24 Hours.

o And if water be then introduced, the gas will be absorbed.

One Volume of water will absorb 480 volumes of this gas.

the plant, to the nourishment & support of which it contributes, &
the oxygene is set at liberty.

Water is never found quite pure as it is always mixed with some
air, & often with metallic solutions; whenever water is mentioned
as an agent in any chemical combination, pure distilled
water is to be understood.x

Water is contained in the air of the atmosphere, even during the
driest weather.

It becomes solid in the state of ice at 32° Fahrenheit, & elastic at
212°. its maximum of density is at 40°, below & above which
point it always expands.

The numbers of the bodies already mentioned in reference to hydrogen
by weight are (hydrogen being 1) Oxy = ~~15~~ Chlorine = 36 and
Iodine 125. and Water 9.

Of Muriatic acid gas.

Hydrogene & Chlorine unite in equal proportions to form
Muriatic acid gas, or as it is sometimes called Hydrochloric Acid.
To make the combination, it is only necessary to expose a mixture
of equal parts of the two gases to daylight. ~~of the~~ in a certain
time, the Chlorine will have lost its colour, & have combined
with the ~~Hydrogen~~ ~~Oxygene~~; there will be no notable condensation, &
the result is a peculiar elastic fluid, called Muriatic acid
gas. o

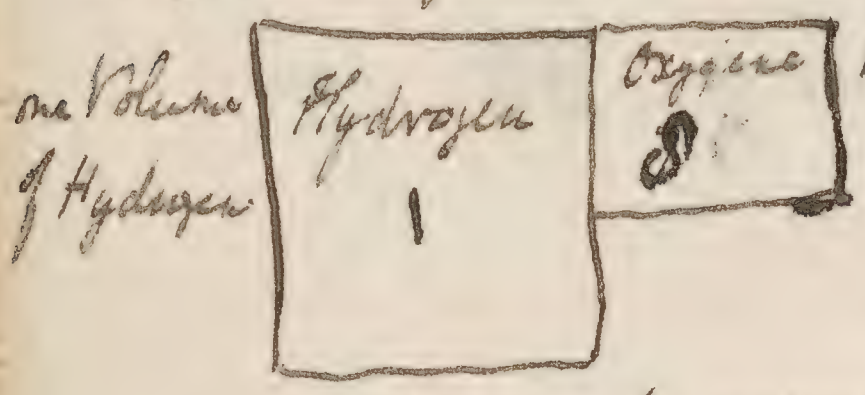
By exposure to direct solar light they explode; they likewise explode by the electric spark; the result in this case, as the latter; 1 volume of hydrogene unites to 1 in volume of Chlorine, or 1 in weight to 36. . 1 no change of volume takes place. It is an acid gaseous body, & changes vegetable blues to red.

Its number with reference to Hydrogen is 37. . 1 100 cubical inches of it weigh 39.60 grains.

Hydrogen & Chlorine unite only in one proportion, forming this acid gas.

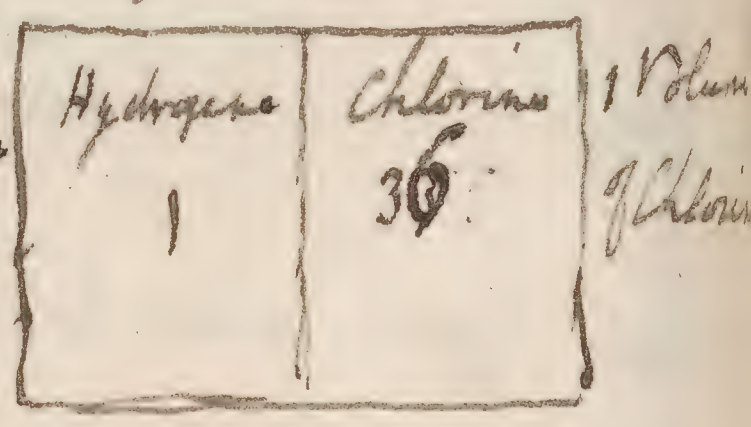
Symbols

Composition of Water



Consequently the number expressing water is 9.

Composition of Muriatic Acid



Consequently the number expressing Muriatic acid is 37.

If into a flask repl full of Chlorine standing over water kept with the
repulsion of Letters, an inflamed current of hydrogen gas be introduced, these
gases combine in equal proportions, a Muriatic acid gas is formed, & the
flue water will become red, indicating the change to condensation
the water will become red, indicating the change to condensation

Lapperes

If a mixture of equal volumes of Hydrogen & Chlorine gases be inflamed
in a strong detonating repul, nothing but Muriatic acid remains, but of any
a large quantity of water happen to exist in the tube the gas is immediately
absorbed by it.

The two volumes of Hydrogen & Chlorine in combining to form Muriatic
acid undergo no change of bulk

Muriatic acid gas may be decomposed by the action of several
of the metals, which have a strong attraction for the Chlorine. Potassium
for instance, absorbs the Chlorine, & the hydrogen remains, & the
Muriatic acid gas thus affords half its volume of hydrogen.

This gas is perfectly clear & transparent when new & confined, but
when in contact of atmospheric air, it takes the form of fumes or
vapor from combining with the moisture in the air.

In order to effect the Analysis of Muriatic acid gas, some substance must be presented to it, having a greater attraction for the Chlorine than the hydrogen has. thus if Potassium be heated in Muriatic acid, it absorbs the Chlorine, half the volume remains, which is hydrogen. proving that Muriatic gas consists of hydrogen & Chlorine in equal proportions.
If the Potassium be too much heated the vessel will frequently break, & the result of the experiment will be frustrated. but if be gently & gradually heated, it takes up more time, but the Chlorine is more quietly absorbed.
a very small quantity of water is capable of absorbing a large quantity of this gas.

+ That is it does not support the combustion of a candle.
the potassium will burn in it.

Muriatic acid gas has been condensed into a liquid form this quite free from water by a pressure of 40 atmospheres.

Peroxide of lead will decompose Muriatic acid, for if the acid be poured on the lead, the hydrogen of the acid will combine with the oxygen of the oxide, the chlorine is liberated, & a solution of chloride is the result.

+ The Sodium must be moistened; or the Phosphorus must, for the presence of water is of course necessary to produce the hydrogen. for the water is decomposed, the oxygen uniting with the phosphorus, & the hydrogen to the Sodium to form the Hydriodic acid. a strong attraction exists

Lecture 19th

Of Muriatic Acid, & Properties of the Gas.

Muriatic acid gas is procured by the action of sulphuric acid upon common salt or sal ammoniac. it cannot without the application of heat; some litmus paper should be introduced into the neck of the retort, to prevent any fluid acid from soiling the mercury over which it must be collected. & the neck of the receiver should be made sufficiently large & allowed to become cold before heat is applied.

The gas is neither combustible, nor supports combustion.

It reddens litmus paper; when suffered to issue into the atmosphere, it produces white fumes by uniting to the aqueous vapour of the air, owing to its combining with water & moisture with great avidity.

Its specific gravity is to that of Hydrogen as 1.8750 to 1.

This gas is very rapidly absorbed by water, therefore must be collected over mercury; as water absorbs about 480 times its bulk of gas, & forms liquid Muriatic acid, commonly called Spirit of Salt.

It is a solution of Muriatic acid gas in water.

The best proportions for procuring it are 32 parts of salt, & 22 parts of Sulphuric acid diluted with about an third weight of water.

Its specific gravity is in proportion to the quantity of gas it contains.

~~Of Nitrogen or Azote~~
Of the Compound of Hydrogen & Iodine.

Hydrogen & Iodine excite a slow action on each other, & produce the Hydriodic acid; it may be procured by a mixture of Iodine & Phosphorus. It forms like muriatic acid a reddish vapour that blues. It is a substance whose properties are but little

known, & of little importance, but used as a chemical test.

Of Nitrogen or Azote.

Nitrogen is a component part of common air, & may be procured by extracting Oxygene from it, by means of the combustion of Phosphorus or by a mixture of Sulphur & iron filings.+

It is also formed by distilling any animal matter, among others from cheese, in diluted nitric acid, & may be collected over water.

It is not respirable, nor promotes combustion, but is acidifiable

Its specific gravity is to that of Hydrogene as 13 to 1. 100 cubical inches of it weighs between 29 & 30 grains.

Of the Compounds of Nitrogen with Oxygen, & Nitrous Oxyde.

There are several compounds containing Nitrogen & Oxygene in different proportions.+

The first is Nitrous Oxyde, or gaseous oxyde of Azote, the compound containing the smallest quantity of oxygene

It is a gaseous body, & may be procured by heating Nitrate of Ammonia gently by the flame of an Argand lamp, taking care that the heat be not too great, or the decomposition of the salt will take place too rapidly, & the vessel will burst.+

It may be collected for immediate experiment over water, but for accurate observation it should be collected over mercury, as water absorbs it to a certain degree.

A taper plunged into it burns with great brilliancy

When Sulphur or Phosphorus slightly inflamed are introduced

Nitrogen.

14

Nitrogen is acidifiable but not combustible

+ Heat is nothing more than decomposing the air of the atmosphere by taking away its oxygen, the water vile of course rise in the glass in proportion to the oxygen absorbed.

Nitrogen tho' never yet actually decomposed is supposed to be a compound substance.

Nitrogen will not combine with other substances when in a free or insulated state, but only when in a nascent state that arising from other substances which contain it.

It forms four compounds with oxygen, two of which are Oxides viz the Nitrous Oxide; the Nitric oxide or Nitrous gas; the Nitrous acid gas; the Nitric acid.

+ It must not be heated with a charcoal fire, but there is no danger of gently heated by an argand lamp.

+Because Sulphur & Phosphorus at a high temperature have the power of abstracting ~~it~~ oxygen; but not at a low temperature

Its easily absorbed by water, which takes up about its own bulk, & woles it unchanged when heated.

into it, they are extinguished, but if already burning with a considerable flame, their combustion is much increased, & that those substances require a higher degree of heat for their combustion in it than they require in oxygene or in common air.

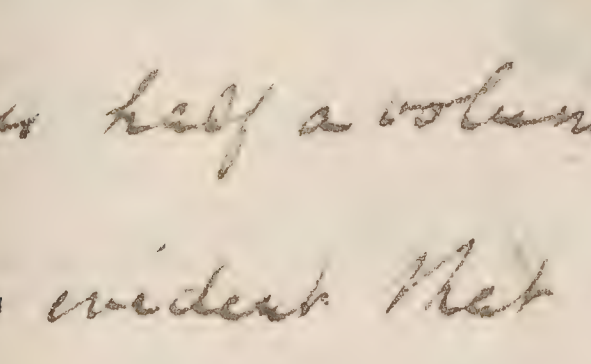
Its specific gravity is that of hydrogene as 20 5/6 : 1. 100 cubical inches of it at a mean temperature & pressure weigh about 40 grains.

It is respirable, but not fitted to support life: when respired it produces effects like transient intoxication: individuals that differ in temperament are however differently affected, & the breathing it is sometimes injurious, particularly to those subject to a determination of blood to the head.

The nature of Nitrous Oxyde is thus shown.

When one volume of Nitrous oxyde is mixed with one volume of hydrogene, & an electric shock is passed thro' the mixture, inflammation takes place, water is formed, & one volume of elastic matter remains, which is Nitrogen. now as one volume of Hydrogene takes half a volume of Oxygene for its conversion into water, it is evident that this gas, Nitrous Oxyde, must be composed of one in volume of Nitrogen, & 1/2 in volume of Oxygene, condensed into a space equal to one.

So that it consists of ~~two parts of Nitrogen~~ (one part of Nitrogen being expressed by 14) & 8 (or one part) of Oxygene.



Therefore its representative number is ~~20~~ 22.

Of Nitric Oxide, or Nitrous Gas.

Nitrous gas is procured by the action of metals on nitric acid, by depositing some turnings of copper in diluted nitric acid, & may be received over water.*

It is very slightly absorbable by water, & for accurate experiments mercury should be employed. ⊕

When a vessel of Nitrous gas is opened in the atmosphere, red fumes immediately appear

It is neither respirable nor a supporter of combustion. ⊖

Its specific gravity is that of Hydrogen as 15·51. 100 cubical inches of it weigh about 345 grains. Its specific gravity as to air is 1·043. whether it is respirable cannot be ascertained, as it instantly unites with the oxygene of the air, producing red fumes, which are nitrous acid gas.

It consists of 14 of Nitrogen to 16 of Oxygene. So that it contains double the quantity of Oxygen which Nitrous Oxyde does.

Nitrous Gas is represented by the number 30 being a compound of 14 of Nitrogen & 16 of Oxygen.
one proportion — two proportions

Symbol

Nitrogen	Oxygen
14	16

one Part of N — two Parts Oxygen

Thus represented by the Number 30

+ It is in fact procuring some substance to Nitric acid, which absorbs part of its oxygen. The nitric acid should be diluted with about 3 or 4 parts of water.

when perfectly pure, & no common air be admitted, it is not acid, but if air be admitted, it becomes nitrous acid gas.

⊕ When mixed with air & converted into nitrous acid gas, it becomes perfectly soluble in water.

o It extinguishes most burning bodies, but phosphorus readily burns in it, if introduced in intense ignition.

§ It does not detonate when mixed with hydrogen & subjected to the electric spark; but it may be decomposed by the action of some of the metals at high temperatures, which absorb its oxygen. One volume of Nitric oxide or Nitrous gas, is thus resolved into equal volumes of Oxygen & Nitrogen.

When Nitrogen & Oxygen are mingled together, in whatever proportions they are employed no combination ensues. The result is a simple mixture of the two gases, which do not like inelastic fluids, remain on standing; but remain diffused thro' each other; this is the case with the air of our atmosphere, & it is fortunate that such a tendency of nature exists, since the atmosphere contains the elements of several combinations, which if actually formed, would be fatal to animal & vegetable life.

When however either or both of these elements is a condensed state or deprived of a part of their caloric which keeps the particles of the gases at a distance from each other, they unite & form compounds

distinguished by very striking properties.

It was formerly thought that Chlorine contained oxygen, because when mixed with nitrous gas, it caused yellow fumes. but this error arose from the presence of water which contains oxygen, & it was afterwards found that when the gases are perfectly dry no change of colour is produced.

+ a great absorption takes place, & it is found to be an acid by changing vegetable blues to red.

The gases are condensed into about one half their volume

It is obvious from this experiment that nitrous acid gas must consist of 1/4 or one volume of Nitrogen + 3/2 Oxygen.

If the mixture of nitrous gas & oxygen be made over water, in the above proportions, & if the gases be perfectly pure, complete absorption takes place; but if either the oxygen or nitrous gas contain uncombined nitrogen, it will remain unabsorbed.

Lecture 18th.

Of Nitrous Acid Gas.

It has been mentioned that the red fumes produced by the action of oxygene & Nitrous gas, owing to the production of Nitrous acid gas. The proportions of its elements have been investigated by Sir H Davy who finds, that when two measures of Nitrous Oxide, & one of Oxygene freed from moisture are mixed together in a vessel previously exhausted of air, they become condensed to about one half of their volume, & form a deep orange coloured elastic fluid, which may be called Nitrous acid gas +

It takes burns in it with considerable brilliancy.

When a portion of water is exposed to it, there is a rapid absorption & the water gains a tint of green.

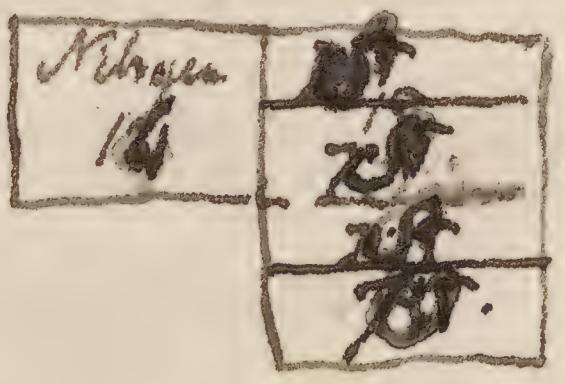
Its smell is disagreeable & taste sour.

In Calculating from the condensation, the Specific gravity of Nitrous acid gas is to that of hydrogene as about 28 : 1 & 100 cubic inches of it weigh 68.2 grains. its Specific gravity to air is as 2.13

It is composed of 2 volumes of Oxygen & one of Nitrogen

Symbol

one Part of Nitrogen



Therefore the number representing it is 46.

Of Nitric Acid.

Nitric acid is procured by the distillation of Nitre & Sulphuric acid; 3 parts of nitre & 2 of acid are the best proportions.

This substance acts with great violence on all the metals ancciently known except gold & Platinum, & causes volatile oils to inflame.

The acid is usually [illegible], but becomes Colourless by exposure to air, its colour is caused by the nitrous acid gas it contains.

It is composed of Nitrous acid gas, Oxygene & water

It is perfectly colourless when pure, it is sour & corrosive, & converts vegetable blues Red.

It is employed in medicine, for dissolving metals, for Etching, for making compounds used in dyeing, & it is one of the constituent parts of nitre.

Of the Compounds of Nitrogen with Chlorine & Iodine

These form very explosive substances, which are more curious than useful; they detonate most violently, & the exact nature of them little is known. S

Of the Compounds of Nitrogen with Hydrogene, forming Ammonia.

Nitrogen & Hydrogene exist in combination in Ammonia or volatile alkali. it is not easy to produce their union, yet when nitrogen is exposed to moist substances giving off hydrogene, a little ammonia is found some time after in the water.

To procure Ammonia two parts of dry quick lime, & one of sal

The Nitric acid of commerce is frequently polluted by the presence of sulphuric acid & of Muriatic acid. Which when the process is not conducted with great nicety, will arise from the materials. The former may be separated by Nitrate of Baryta, & the latter by Nitrate of Silver.

It absorbs the vapours of water, & exhales white fumes.

The proportion of dry Nitric acid uncombined with water, that is here combined in the state of Nitrates, (for the acid cannot be exhibited in a simple state) is one proportion of Nitrogen = 13, & five of oxygen = 37.5

& is thus represented

Nitric acid

N	Ox
14	O
	O
	O
	O
	O

The Number is therefore 54.

But in its liquid state it always contains water, & when in this state its specific gravity is 1.5, & it may be regarded as a compound of one proportional of dry acid & two of water, thus Acid 54 + Water 18 = 72 liquid Acid.

Nitric acid may be decomposed by passing its vapours thro' red hot porcelain tubes; oxygen is given off, nitrous acid gas is produced, & a quantity of diluted acid passes over into the receiver, having escaped decomposition: so that it is thus proved to consist of nitrous acid gas, oxygen & water.

When nitric acid & muriatic acid are mixed, they acquire the power of dissolving gold, which neither of the acids possessed separately. Chlorine is formed, which produces this effect.

The Nitric acid parts so readily with its oxygen, as to become a very powerful oxidizer.

Nitrogen & Chlorine do not unite directly, but the compound may be obtained by exposing a solution of Nitrate or Muriate of Ammonia to the action of Chlorine at a temperature of 60° or 70. The gas

is absorbed, & an oil like fluid, heavier than water is produced. it is not compelled by cold. this substance is dangerously explosive & is decomposed with violent detonation by only touching it with some combustible bodies, especially blotting paper & fixed oils.

The compound of Nitrogen & Iodine may be procured by pouring a solution of ammonia upon a very small quantity of Iodine. the hydriodic acid is one product, & the other a brown powder, which detonates upon the slightest touch, & is resolved into nitrogen & iodine. when left exposed to the air it gradually evaporates

+ But these four volumes are condensed into two

Ammoniac, are heated in a glass retort, the beak of which is plunged under dry mercury, over which the gas must be collected.

The specific gravity of Ammonia is 590 that of hydrogene, nearly as 590 to 1,100 cubical inches of it weigh about 10 grains

When an inflamed taper is plunged into ammonia, the light is extinguished, but a slight inflammation of the gas occurs when it is in contact with air.

It is the principle which gives pungency to the common concrete volatile alkali, called smelling Salts.

It instantly reddens paper tinged with turmeric, & gives a green colour to most vegetable blues & reds, & this property, and its other properties, characterise it as an alkaline body.

It is very rapidly absorbed by water; at the temperature of 50° water absorbs about 670 times its volume of gas, & becomes liquid Ammonia.

In the most accurate experiments in which the hydrogene has been separated from the nitrogen; the volumes have been 3 of hydrogene to one of Nitrogen +

Symbol of the Composition of Ammonia.

Hydrogen 3	Nitrogen 14
1	
1	

3 parts of Hydrogen — one part of Nitrogen

Therefore the number representing it is 17.

~~It would appear~~

Lecture 19th.

Subject of Ammonia continued, & of Ammoniacal Salts.

The constitution of Ammonia may be easily demonstrated by analytical experiments, it is decomposed by electrical sparks, or by being passed thro' a tube heated to redness; its volume is encreased, & it becomes hydrogene & nitrogene +

Suppose it was required to calculate the quantity of these gases in a certain quantity of Ammonia

We will take for example 10 measures of Ammoniacal gas, which by repeated electrical sparks being passed thro' it, is expanded to 10 measures, & then suffers no further increase of bulk. I then add 8 measures of Oxygene gas, & after causing it to explode, I find the bulk is reduced to 6 measures, so that 20 measures have disappeared. I then divide this by 3

3) 20 (6·66
10
20

Then multiply these measures by 2 to find the measures of Hydrogen, & the remainder is Nitrogen

6·66
2
13·32 = Measures of Hydrogen

So that 10 measures of Ammonia ~~upon by Electricity~~ contain 13·32 of Hydrogene

& 4·68 of Nitrogen.

When Nitric acid is violently acted upon by tin filings, Ammonia is produced in small quantities. +

It is generally obtained in the manufactories from animal

The usual state in which Ammonia is employed is in solution. it may be obtained by passing the gas into water by means of the Wolfe's apparatus, or by distilling over the water & the gas together according to the following process.

Take 8 ounces of well burned lime powder half a pint of water, & when it is cool, add 12 ounces of chloride of Ammonia in powder & three pints & a half of boiling water; when the mixture has cooled pour off the clear portion & distill from a retort 20 fluid ounces.

+ That is it is decomposed into its elements of one volume of nitrogen & 3 of hydrogen gases, furnishing a most singular instance of change of properties in consequence of chemical combination, for its elements (hydrogen & nitrogen) are unabsorbable by water, & void of smell, whereas Ammonia is very largely absorbed by water & is extremely pungent.

If Ammoniacal gas be passed over oxide of Manganese in a red hot tube, it is converted into Nitrous acid gas & water. ~~& oxygen~~ a portion of the hydrogen uniting to the oxygen of the oxide to form water, & the nitrogen uniting to the remaining oxigen to produce the nitrous acid.

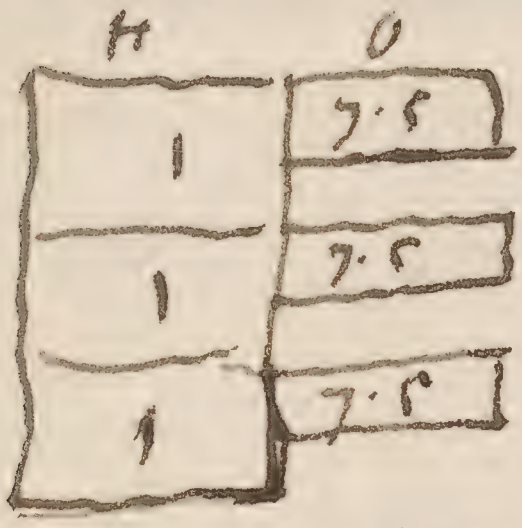
+ Owing to the violent decomposition of the liquid nitric acid, which contain its elements, which when in a nascent state combine to form a portion of Ammonia.

+ This salt as we have seen before is the source of Nitrous Oxide, & when heated is entirely resolved into that gas, & water.
It consist of one proportional of nitric acid = 50·5 + one proportional of ammonia = 16, Therefore the representative number of this salt is 66·5, or it may be considered as 2 proportionals of nitrogen 3 of hydrogen & 5 of oxygen, thus

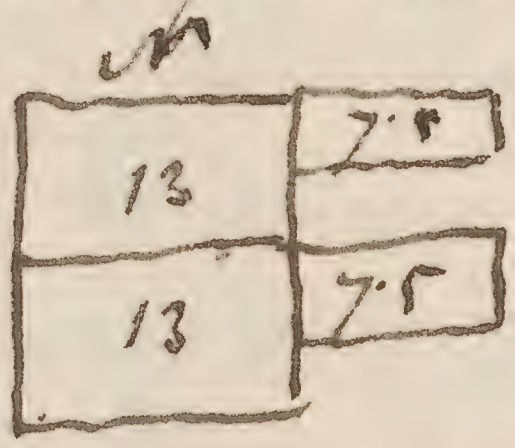
Nitrate of Ammonia

which when decomposed by heat is resolved into water & nitrous oxide, & will be thus represented, forming 3 proportionals of water & 2 of nitrous oxide, & no other product ever result.

3 Prop.ls of water



2 Prop.ls of Nitrous Oxide



This salt is of little use, but is a curious illustration of the theory of definite proportions.

Is commonly called Sal Ammoniac.

matter, which consists of the constituent parts of Ammonia
namely Nitrogene & hydrogene.

Of Nitrate of Ammonia +

Nitric Acid.
Nitrate of Ammonia is the compound of Ammonia with ~~Nitre~~.
& may be made by adding carbonate of ammonia to dilute Nitric
acid till saturation takes place, the liquor is then slowly evaporated
& the salt crystallises.
Nitric acid dropped into Ammonia also forms nitrate of Ammonia

Of Muriate of Ammonia. ⊕

If equal measures of ammoniacal gas & muriatic acid gas
be mixed together, they are immediately & totally condensed, a
white cloud is formed, & a solid substance is deposited on the sides
of the vessel. This is Muriate of Ammonia commonly called
Sal Ammoniac.
From the white fumes which allways appear on the mixture
of ammoniacal gas with muriatic acid gas, they are excellent
tests for the presence of each other, & the fumes are occasioned
by the union of the gaseous alkali with the gaseous acid.

Of Chlorate of Ammonia.

This salt may be formed by adding a solution of Chlorine, to a
solution of Ammonia till the effervescence ceases, then the solution
must be evaporated by a very gentle heat.

# of Atmospheric Air.

Atmospheric air is a mixture of Oxygen & Nitrogene gases, the former of these seems to be the only ingredient upon which its chemical qualities depend.

Hence combustible bodies only burn in it as long as any oxygen remains in it, & animal life is supported only in consequence of the oxygen it contains.

Air has weight, & the weight of our atmosphere is equal to 33 feet of water and 30 inches of mercury at a mean temperature & pressure.

Hence water cannot be raised higher than 33 feet by a common sucking pump, & when a barometer is placed under an exhausted receiver, the pressure is removed & the mercury falls; when the air is readmitted, it again rises.

And as the weight & pressure of the atmosphere is less, the higher we ascend, the height of mountains may be ascertained by the relative sinking of the barometer.

The general rule for ascertaining the purity of atmospheric air by hydrogen gas is as follows: add to 3 measures of air under examination, 2 measures of pure hydrogene gas, inflame the mixture by electricity, observe the diminution when the vessel has cooled; & dividing its amount by 3, we obtain pretty nearly the quantity of oxygen gas which has been condensed.

+ That air has weight, was first suspected by Galileo, who found that a copper ball, in which the air had been condensed, weighed heavier than when in its ordinary state. This fact was afterwards demonstrated by Torricelli. a tube has been dug to a depth of 40 feet & a common sucking pump was applied to raise the water, & it was found to the great astonishment of the philosophers of Florence (who were then unacquainted with the cause) that the water would only rise in the pipe to the height of 33 feet & was then stationary, tho the pump continued to act as well as before: Torricelli suspecting that the weight of the atmosphere (& not as was foolishly then supposed Nature's abhorrence of a vacuum) was the cause of the ascent of the water in the pipe, filled a glass tube 3 feet long, & closed at one end, with quicksilver, & inverted it in a bason of the same fluid; he found that the mercury fell about 6 inches, & that the atmosphere appeared capable of counterbalancing a column of mercury of 30 inches in height, or a column of water of 33 feet.

It was afterwards found that upon ascending a mountain, the quicksilver fell in the tube, because there was less air above to press upon the surface of metal in the basin

Thus the barometer indicates by its rise & fall, a correspondent change in the density of the atmosphere. at the surface of the earth the mean density or pressure is considered equal to the support of a column of quicksilver of 30 inches high.

Lecture 20th.

Same Subject continued.

Atmospheric air, as is proved by experiment, contains 21 parts of oxygen out of every 100; & contains therefore 21 per cent of oxygen & 79 of Nitrogen by measure.

And this is found to be the case in the atmospheres of different places, from which it appears that the purity & salubrity of the air depend upon some other circumstances than the proportion of its elements.

The weight of 100 cubic inches of air (at mean temperature and pressure that is at 30 inches of the barometer, & 60° Fahrenheit) is 30.75 grains.

In order to weigh air exactly, it must be collected over mercury & dried by substances which absorb its moisture, such as potash or sulphuric acid.

There are various methods of ascertaining the purity of air. ⊕

Sulphate of Iron has the property of absorbing the oxygene & not the nitrogene, hence air exposed to a solution of this substance will diminish in bulk as the oxygen will be absorbed, & can be measured by the quantity of the solution which rises in the tube to supply the place of the absorption.

Nitrous gas has a similar property, & is likewise used as a hydrometer.

The mechanical properties of air, such as its elasticity, pressure &c are easily shown by various experiments with the air pump; the explanation of these properties more properly belong to natural philosophy than Chemistry

The proportions of Oxygen & Nitrogen in atmospheric air, are as 20 to 80 by measure, and 23 to 77 by weight. & when these gases are mixed in these proportions it forms a compound, having all the properties of common air; it supports combustion in the same manner & animals can breath & live in it; but if they are mixed in any other proportion its properties are changed.

Besides these gases, common air always contains a very small quantity of carbonic acid & aqueous vapour.

+ About one peck in every hundred lost.

†Roll sulphur is chiefly obtained from sulphuret of copper in this country; which is roasted, & the fumes passed into a long chamber of brick-work, where the sulphur is gradually deposited: it is then purified by fusion, cast into sticks.

& It combines with Oxygen in 4 proportions, but two of the compounds are of no use or moment.

⊕ Water takes up rather more than 30 times its bulk of this gas, forming the liquid sulphurous acid, which destroys many vegetable colours, but by keeping acquires a true flavour, & adds the generality of vegetable blue.

Lecture 21st

On Sulphur & its Combinations.

Sulphur is a well known substance found native in many places, but generally combined with various other substances from which it is obtained pure by sublimation.

Its Specific gravity is 1990 water being 1000. number representing it S_{16}^{32} is most usually obtained from its combination with copper. when heated to 180° it volatilizes & gives out a disagreable smell, at 225° it fuses & becomes a deep brown liquid, at 400° it becomes viscid, & at 600° it sublimes & becomes an elastic fluid, which upon cooling is condensed & becomes what is commonly called flowers of Sulphur.

It combines with Oxygene in two proportions ⊖; one called Sulphurious acid gas, the other Sulphuric acid.

Sulphureous acid gas may be obtained by burning Sulphur in Oxygene gas, & likewise by heating mercury or copper filings in Sulphuric acid, & collecting over mercury ⊕, & in this last case, the oxygene is extracted from the Sulphuric acid by the action of the mercury.

Sulphureous acid consists nearly of equal parts of Oxygene & Sulphur by weight. the number representing it is 32

The fumes of this acid are capable of ~~destroying~~ bleaching many of the vegetable blues, & whites many vegetable substances, either by its

Known employed in bleaching.

Its specific gravity is to that of hydrogene as 32 to 1, and 100 cubic inches of it weigh about 60 grains.

As it is absorbed by water, it must be collected over mercury.

It neither supports combustion nor respiration.

Its combination with Ammonia is called Sulphite of Ammonia

Sulphuric Acid.

Sulphuric acid contains Sulphur combined with more Oxygene than in Sulphureous acid *

It is made by burning 8 parts of sulphur with one of nitre in jars of lead communicating with a chamber of lead, the bottom of which is covered with water, which absorbs the gas as it is formed. ⊗

Its Specific gravity is 1·85 water being 1·

This acid is a very corrosive substance; it acts with great energy upon animal & vegetable matter. it rapidly attracts moisture from the air, & produces much heat when mixed with water, owing to heat being given out on the condensation of these fluids. the smallest quantity of it diluted with a large portion of water reddens vegetable blues. it acts with great violence upon alkaline substances, & upon certain earths & metallic oxides, producing neutral salts.

From its attracting moisture so speedily, it is often used as a hydrometrical fluid.

Sulphurous acid is composed of equal weights of Sulphur & oxygen

S	O
16	8 / 8

Its number therefore is 32

and the above figure represents it.
and it is formed without change of volume.

~~But the two volumes of Sulphur & Oxygen are condensed into one~~

Sulphurous gas may be condensed into a liquid form by a temperature of 14 above 0.

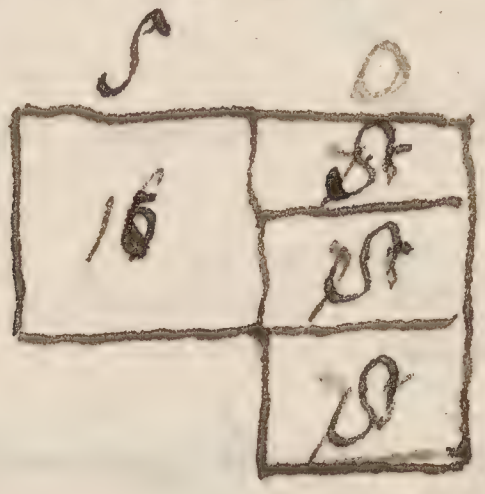
The Number representing Sulphuric acid, when dry is = 40 That is

16 Sulphur + three proportionals of Oxygen 24 = 40

But in its usual liquid State when mixed with water, is thus represented

Sul Oxy Water
16 + 24 + 9 = 49 & Representative number of oil of Vitriol
or as this sometimes called hydrated Sulp^{c} Acid.

The following figure show the composition of Sulphuric Acid

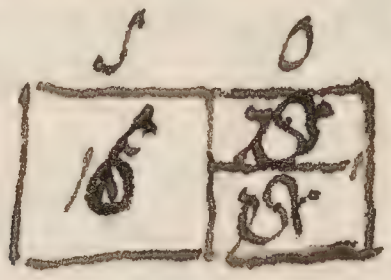


Its number is 40.

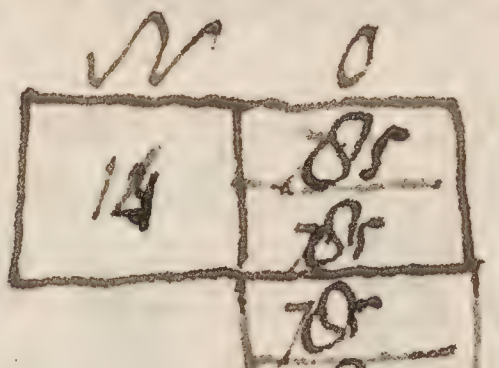
but when in a liquid state it contains one proportional of water

its Measure represented by the number 40 + 9 = 49

Sulphurous Acid consists of



Nitrous Acid consists of

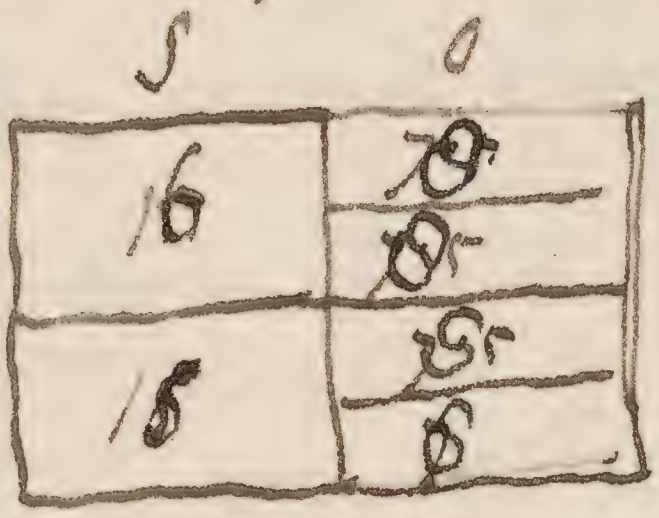


Hence every two portions of Sulphurous acid require one of

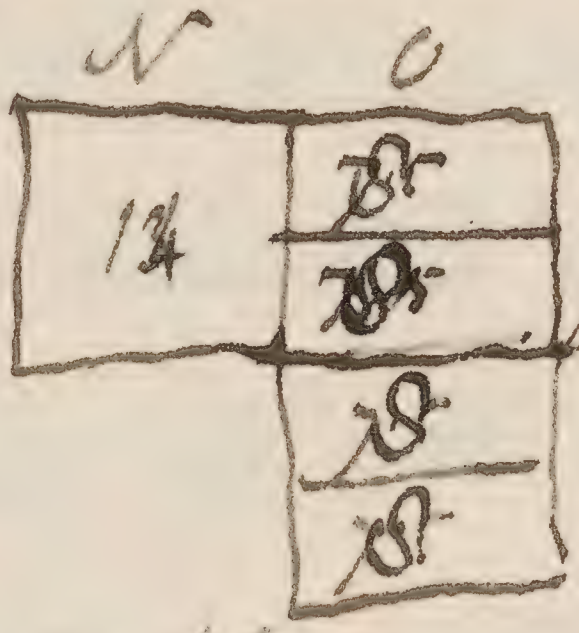
Nitrous acid, which transfers two of oxygen, & passes back into it.

state of Nitrous gas, Sulphuric acid being at the same time produced.

The gases thereafter before decomposition, may be thus represented.

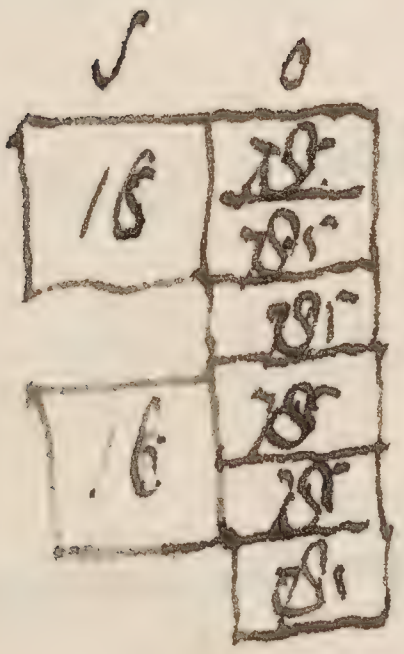


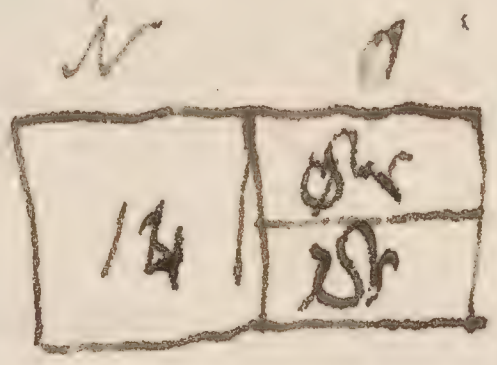
2. Propns of Sulphurous acid.



One of Nitrous acid gas.

After decomposition as follows.





Nitric acid

two Propns of Sulphuric Acid

on this principle of its attraction for water, is to be explained also, the rapid increase of weight, which the acid acquires when exposed to the air.

The following is the theory of the process of its formation.

The sulphur by burning forms sulphurous acid gas, & the acid in the nitre is decomposed, giving off nitrous gas; this coming in contact with the oxygene of the atmosphere, produces nitrous acid gas, which has no action upon sulphurous acid, to convert it to sulphuric acid, unless water be present; if this substance be only in certain proportions, the water the nitrous acid gas, & the sulphurous acid gas combine, & form a white crystalline solid: by the large quantity of water employed, this compound is instantly decomposed, sulphuric acid is formed, & nitrous gas given off, which in the air becomes nitrous acid gas, & the process continues according to the same principle of combination and decomposition, till the water at the bottom of the chamber is become strongly acid.

To prove the truth of this reasoning, let dry sulphurous acid gas & nitrous acid gas be mixed together; there will then be no action between the gases; but if a drop of water be introduced there will be an immediate

condensation, & a white crystalline solid will line the interior of the vessel; whereas if more water be introduced, nitrous gas will be given off, & the water will become a solution of sulphuric acid.

The sulphate of Ammonia consists of one proportional of Sulphuric acid (37.5) & one of Ammonia (16). its number therefore is

53.5.

It is obtained by keeping Ammonia into Sulphuric acid; but is usually prepared by saturating dilute Sulphuric acid with carbonate of Ammonia, & suffering it to crystallize. when boiled this salt gives off Ammonia, & a supersulphate remains.

The strength of Sulphuric acid is best judged of by its saturating power, & by its Specific gravity, whereas by its boiling point, as the strongest requires the greatest heat to make it boil.

The decomposition of this acid may be effected by passing it thro' a red hot platinum tube, when it is resolved into sulphurous acid oxygen, & water.

It is used in a variety of manufactures: by the makers of nitric, muriatic, citric & tartaric acids; by bleachers, dyers, tin-plate makers & gilders

If upon being mixed with water it becomes turbid, it is impure & contains a portion of lead.

+ It exists in many mineral waters: in those of Harrowgate, Moffat
& Aix la chapelle.
The best test for the presence of this gas in water is a solution of
lead, which throws down a dark brown or blackish precipitate

Lecture 22

On the further Combination of Sulphur.

Sulphur & Chlorine are possessed of a chemical attraction for each other; & the Chloride of Sulphur consists of one proportion of each of its constituents, that is of 15 by weight of Sulphur & 33'5 of Chlorine its representative number therefore is 40·5.

This formed by heating Sulphur in a retort filled with Chlorine, then substances then combine & form a fluid substance, which distils into the cool part of the retort.

It does not redden perfectly dry paper tinged with litmus, but when mixed with water, it becomes acid, & contains sulphurous acid, from the oxygen of the water combining with the sulphur.

Of Sulphuretted Hydrogene gas.

+Sulphuretted Hydrogene gas is made by the action of diluted sulphuric acid upon a mixture of 3 parts of iron filings & 2 of Sulphur that have been ignited together, it may be collected over water, but for the purposes of accurate experiment, it should be collected over mercury.

It inflames by a lighted taper, but does not support combustion; it burns with a pale blue flame & deposits sulphur. its smell is extremely fetid & its taste sour. it reddens vegetable blues, & its solution is an excellent test for the presence of metals, it precipitates them of different colours.

Its weight to that of hydrogene may be considered as 16 to 1,

Therefore its representative number is 16, & 100 cubical inches of it weigh 36 grains.

The composition of this gas is shown by the change produced in it by electricity; sulphur is deposited & an equal volume of Hydrogen remains.

The proportion of its elements are shown both the same both by synthesis & analysis. They must be 15 of Sulphur & 1 of Hydrogen.

This decomposed by Chlorine & nitric acid, & deposits sulphur as the mixture instantaneously.

Of Sulphuretted Ammonia. *

Sulphuretted Hydrogen gas combines with an equal volume of Ammonia, to form sulphuret of Ammonia.

Sulphur also combines with Iodine, & forms a compound little known

It has no chemical attraction for nitrogene, at least no compound of these bodies has as yet been found.

Of Phosphorus & its Combinations.

+ Phosphorus is made by a mixture of burnt bones & sulphuric acid. The bones being calcined are freed from animal matter, as phosphate of lime, the sulphuric acid unites to the lime; & the phosphoric acid is set at liberty. it is not necessary here to describe the process.

Phosphorus is semitransparent, soft & more ductile than wax, it is insoluble in water; it melts at the temperature of 90°, & boils at about 550°.

+ ~~Sulphuretted hydrogen gas throws readily into equal~~ ~~colours.~~ White fumes at first appear, which become yellow, & a yellow crystallized compound results.

It distinguishes as a test for the presence of metals, almost all of which it precipitates from their solutions, forming precipitates of different colours according to the particular metal in solution.

Sulphuretted hydrogen & hydrosulphuret of Ammonia do not precipitate them of the same colour, owing to the combination of the Ammonia of the latter compound.

It may be procured by distilling at nearly a red heat a mixture of 6 parts of Muriated Lime, 2 of Muriate of Ammonia, & 1 Sulphur.

+ This obtained also by distilling Phosphoric acid with an equal weight of charcoal at a red heat. This mixture is put into a coated glass or earthen retort, placed in a small portable furnace; the tube of the retort should be immersed into a basin of water, otherwise if gas at first escapes, some after the phosphorus distills over, it is at first impure, but may be purified by making it under water to pass through a tube of fine charcoal powder.

It was first discovered in the search for the philosophers stone, & was procured from human urine, which contains Phosphoric acid.

+ Is this substance which is generally used in the phosphorus matches
boxes. To prepare it for this purpose a piece of phosphorus may be put
into a small phial, & melted & stirred about so as to coat its interior,
with a hot iron wire. The phial should have a narrow neck.
Its combination with oxygen produces an oxide ~~& acid~~ & true
acids.
The oxide is the white substance with which Phosphorus becomes
incrusted when kept for some time in water; its exact proportion in
combination is not ascertained.
Its acids are the hypophosphorous acid, but little known of
little importance. The phosphorous acid, & the phosphoric acid,
The latter is the most important, may be formed by burning
phosphorus in oxygen gas or with a free access of common air, when
the acid is sent to form in white flocculi, & descends from the sides
of the glass like a shower of snow. This may dissolve & acid, & deposited
in water with a hissing noise producing heat, & immediately
turns vegetables blue to red.
It may also be procured by the decomposition of animal bones,
which contain the phosphoric acid combined with lime. This
is expelled by the sulphuric acid which has a stronger affinity

when exposed to the air at common temperatures it emits a white smoke, which is luminous in the dark. this depends upon its combining with oxygene, & forming an acid which unites to the aqueous vapour of the atmosphere; its representative number is 11.

It combines with Oxygene in three proportions.

When Phosphorus is burnt in highly rarefied air, 3 products are formed from it: a red solid comparatively fixed & requiring about 212° for its fusion; a white & easy volatile substance, which is combustible & soluble in water & has acid properties; and a substance which is strongly acid & not volatile, even at a white heat. the first appears to be a mixture of unburned Phosphorus & phosphorous acid, the second the phosphorous acid, & the third to be phosphoric acid.

Of the Compounds of Phosphorus with Chlorine.

When Chlorine is introduced into an exhausted retort, which contains phosphorus, the phosphorus takes fire, & a white substance rises & condenses on the sides of the retort, which is the ~~Phosphuret~~ of Chlorine. Perchloride of Phosphorus.

The ~~Chloride or Proto~~ Bi-chloride of Phosphorus, contains double quantity of phosphorus.

Phosphorus likewise combines with Ammonia, forming a compound called Phosphit of Ammonia.

Lecture 23.

Same Subject continued, and of Carbon

The Chloride of Phosphorus consists of one proportion of Phosphorus
1 one of Chlorine thus

Phos	Chlorine
11	33·5

Therefore its representative number is 44·5

The Bi-Chloride of Phosphorus consists of one proportion of Phosphorus
2 proportions of Chlorine thus

	33·5
Phos	Chlo
11	33·5

Therefore its representative number is 78.

The properties of the Bichloride of Phosphorus are very peculiar, it is a white substance, very volatile, & rises in a gaseous form at a temperature much below that of boiling water

It acts violently upon water, which it decomposes; its Phosphorus combines with the oxygene, producing phosphoric acid, & its Chlorine with hydrogene forms muriatic acid.

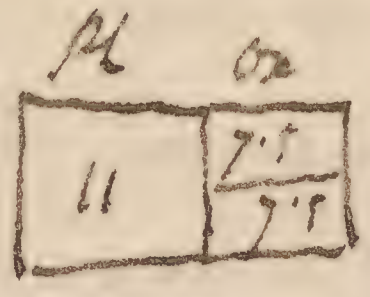
It is analogous to an acid in many of its properties

Phosphorus also combines with Sodium & forms a substance known by the name of Sodate of Phosphorus, it is known little known & of little consequence.

It combines also with Sulphur, forming Sulphuret of Phosphorus

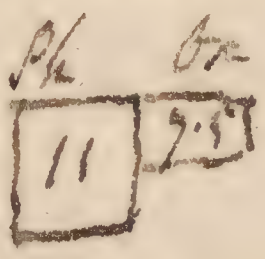
for the time.

This a deliquescent substance; when fused it has been called glacial phosphoric acid. it consists of one proportional of phosphorus & two of oxygen



the number thereof is 26

the phosphorous acid consists of one of phosphorus & one of oxygen.



the number is 18·5.

O Chloride of phosphorus acts upon water with great energy, & produces muriatic & phosphorous acids; like the bichloride hydrous muriatic phosphoric acid; for as in the bichloride there are two proportionals of Chlorine, so in acting upon water, two of oxygen must be evolved, which uniting to one of phosphorus generates phosphoric acid. the chloride of phosphorous on the contrary, containing only one proportional of Chlorine, produces muriatic acid, & phosphorous acid, when it decomposes water.

Before Decomposition

1 Chlorine = 33·5 1 Phosphorus = 11	}	Chloride of Ph' 44·5	1 Hyd = 1 1 Oxy = 7·5	} Water 8·5

after decomposition.

1 Chlorine = 33·5 1 Hyd = 1	}	Muriatic acid 34·5	1 Ph^{s} = 11 1 Oxy^{2} = 7·5	} Phosphorous acid 18·5.

The Chlorate of
Phosphorus forms with Ammonia a singular compound, which tho'
consisting of three very volatile bodies, remains unchanged at a
white heat, & is insoluble in water.

Phosphorus & Nitrogen produce no definite compound, tho' in
some cases of animal decomposition, the evolved nitrogen appears
to hold phosphorus in solution.

When phosphuretted hydrogen is mixed with oxygen, it requires a
volume & a half of the latter gas for its perfect combustion; & as the hydrogen
would require half its volume of oxygen for the production of water, the
remaining volume must unite to the Phosphorus to produce
phosphoric acid.

Of Phosphuretted Hydrogen Gas.

This gas is a compound of Phosphorus & Hydrogene, & has the very peculiar property of inflaming in contact with atmospheric air, It may be procured by heating together a strong solution of caustic potass with phosphorus, or from Phosphuret of Lime in water, which hot as with phosphorus, or from Phosphuret of Lime in water, which is decomposed, & the phosphoretted hydrogene gas is evolved. It is expedient (for fear of its immediate inflammation on coming in contact) to expel from the air contained in the retort in which it is generated by means of oxygene, by burning phosphorus or a taper in it; the gas should be preserved over mercury, as it becomes adulterated by exposure to water containing air; but for many of the immediate purposes of experiment, it may be collected over water.

It inflames immediately & spontaneously on coming in contact with common air, & explodes with a most intense white light in oxygene gas.

Its formation appears to be owing to the decomposition of water, the oxygene of which, with part of the phosphorous acid, forms phosphoric acid, while the hydrogene disposes the excess of Phosphorus existing in the other portion of phosphorous acid, composes the peculiar gas

This is another variety of the gas called the ~~Biphosphoretted hydrogene~~ Hydrophosphorus gas.

The phosphoretted hydrogene gas appears to be constituted of two proportions of hydrogene & one of Phosphorus thus

Hy	Phos
2	11

its representative Number is thus 13.

The ~~Biphosphoretted hydrogen~~ Hydrophosphoric gas consists of one proportion of hydrogene & one of Phosphorus thus

Hy	Ph
1	11

Number is 12.

This last mentioned gas is formed by heating solid hydrat of Phosphorus in a retort out of the contact of air

It has a disagreeable smell, but not quite so fetid as phosphuretted hydrogene; it does not explode spontaneously, but detonates when heated in contact with oxygene; it explodes in chlorine with a white flame.

Of Carbon.

The purest Carbon known is the diamond, & the name carbon signifies the pure inflammable part of charcoal, lamp-black & other similar substances. the purest known form in which it can be obtained is by keeping oils or spirit of wine ~~that~~ ignited under, it then appears as an impalpable black powder. For the common purposes of experiment, charcoal that has been exposed to boiling water, & afterwards ignited to whiteness, is sufficiently pure.

It rapidly attracts moisture from the atmosphere, & is a great antiputrescent, hence vessels used for containing water or any oxygen are always charred, & game or meat may be kept a long while in powdered charcoal. It cannot be fused by any known heat.

+ It has also the power of destroying smell, colour & Taste. The use of throwing charcoal into putrid water; or wrapping it in cloths that have acquired a bad smell; of adding it to sour wine, with a view of making it sweet, depends upon the above properties.

Newly made charcoal has the property of absorbing certain quantities

of the different gases, & it thus increases proportionably in weight.
When exposed to a violent heat out of the contact of air its properties are
unchanged, except that it becomes harder, & will scratch glass like
the diamond, & there is every reason to suppose that if it could be
melted & crystallized it would become diamond.
That the Diamond is only crystallized carbon is proved by
burning it in a current of oxygen gas, when it yields only Carbonic
acid, the same result, as would be produced from charcoal.

+This is much the same sort of process, as the charcoal in this
case deprives the carbonic acid of part of its oxygen, & therefore
converts it into carbonic oxide.

Carbonic oxide may be converted into carbonic acid, by any
means that shall give it an additional proportion of Oxygen,
as by chlorine by it with one proportion of oxygen.

+ Carbonic oxide combines in equal proportions with
Chlorine is exposed to light, & forms a gas of great density
& specific gravity, called Phosgene or Chloro-carbonic acid

Lecture the 24th

of the Compounds of Carbon with Oxygene &c

There are two distinct combinations of Carbon & Oxygene, the Carbonic Oxyde & the Carbonic Acid.

The Carbonic Oxyde contains the least proportion of Oxygene, & may be formed from the Carbonic acid, by presenting to the acid any substance that has the power of attracting from it its oxygene, as by igniting chalk or any substance containing carbonic acid with charcoal iron, tin or zinc, carbonic acid is given out, but these substances deprive it of a part of its oxygene, & it becomes Carbonic Oxyde.

Or it may be formed by passing Carbonic acid gas over charcoal heated to whiteness, in a porcelain tube.

The Carbonic Oxyde may be purified from carbonic ~~oxyde~~ acid, by which it is usually mixed, by washing it in lime water.

It is a combustible body, tho' not a supporter of combustion & burns with a blue flame; if breathed it is fatal to animal life.

Its specific gravity is to that of hydrogene as 13·2 is to 1 and 100 cubical inches weigh 29·7 grains.

Tho' it is inflammable, it contains no hydrogene, as may be shown by its producing no moisture when burnt under a bell glass.

The nature of Carbonic Oxyde, & the proportion of its elements, are easily demonstrated by analytical experiments: when two in volume of it are mixed with one in volume of oxygene, & ignited by the electrical spark, it is decomposed, & two in volume of pure Carbonic acid are formed, a condensation takes place, & the product measures, but the mixture of 3 in volume becomes 2 in

volume of Carbonic acid.
Consequently it is evident carbonic acid contains twice the
quantity of Oxygene as the Carbonic Oxyde.
And from experiments on carbonic acid, & carbonic oxyde, it is
evident, that the number representing Carbon is 5·7, which by
adding one of Oxygene 7·5, becomes Carbonic oxyde, represented by
the number 13·2.

Carbonic Oxyde

Carbon	Oxy.
5·7	7·5

Carbonic acid is formed is formed whenever charcoal or carbonaceous
matter is burnt in air or oxygene; & it is evolved during fermentation,
by the decomposition of animal & vegetable matter, & from
limestone by ignition, or the action of acids.
The easiest way of procuring it, is by the action of dilute
muriatic acid on powdered marble or chalk; it may be
collected for immediate purposes over water, but as this fluid
absorbs a considerable quantity, for accurate experiments, it
must be collected over mercury.
It extinguishes flame, has a peculiar sharp taste, & a faint but
agreable smell it is not respirable. its specific gravity is to
that of hydrogene as 20·7 is to 1. and 100 cubical inches at mean
temperature & pressure weigh 46·57 grains.
Water will absorb ~~twice~~ its volume of this gas at common
temperature & pressure, but if the pressure be increased,
the power of taking it up increases.

No Carbon has a very strong attraction for oxygen, yet the carbonic oxyde may be decomposed by heating Potassium in it, for this metal has a still greater attraction for oxigen than carbon has, when at a high temperature, & carbon is thrown down: & oxyde of Potassium (Potash) is formed, by this simple chemical affinity.

5 As all common combustibles, such as coal, wood, oil, wax, tallow &c contain carbon as one of their component parts, so the combustion of these bodies is always attended by the production of carbonic acid. It is also produced by the respiration of animals; hence it is detected often in considerable proportion in crowded & illuminated rooms, which are ill ventilated. it exists also in very small proportion in the air of the atmosphere.

Water impregnated with Carbonic acid, may be freed from it by boiling, or by placing it under the exhausted receiver of an air pump.

+So that the presence of carbonic acid is quickly detected by lime-water which it renders turbid, & causes a deposit of a white matter, which is carbonate of lime

It is still more readily detected by Baryta water.

+ That happens often in nature, in the case of Stalactites & what are vulgarly called Petrifactions. When water impregnated & charged with carbonic acid is exposed to the air, part of the carbonic acid flies off, & the lime is precipitated in the state of a Carbonate.

+ Or by the simple operation of heat. Thus chalk when heated gives out carbonic acid, & becomes lime

It is easily expelled again from water by boiling, or by placing it under an exhausted receiver.

Carbonic acid is so heavy a gas that it may be poured from one vessel into another containing a lighted taper, the flame of which is immediately extinguished

It has a slight acid quality, it reddens litmus paper, & combines with alkalies & metallic oxydes.

It accumulates in caverns, wells & mines & is known by the name of Chokedamp; it is this gas which from its gravity occupies the lower parts of the caverns of the grotto del Cane in Italy.

It is quickly absorbed by lime water, which becomes turbid on the mixture, depositing a carbonate of Lime; are therefore excellent tests for each other. if the acid be in excess the precipitate is redissolved, as may be seen by pouring a small quantity of the the acid with lime water, which first becomes turbid & on the addition of a larger quantity of acid again become clear. this proves that water impregnated with carbonic acid may contain lime in solution

Plants absorb this gas, & much is produced by respiration of men & animals, there is about one per cent of it contained in atmospheric air.

It is retained in the carbonates by a very feeble affinity, & is easily discharged by the other acids, with effervescence

If the Diamond be burnt, & a stream of oxygene gas be made to
pass over it during ignition, it slowly evaporates, & acts upon the
oxygene in the same manner as charcoal: the volume of the
oxygene is not perceptibly changed, & it is found converted into
carbonic acid.

Hence it has been concluded that the Diamond is pure charcoal
in exactly similar results ensue on their combustion; the identity
of the two bodies is demonstrated; their chemical nature is the
same, & they differ only in their mechanical properties. It is
always resolved into carbonic acid; 5 grains of pure charcoal
produces exactly the same substance in the same quantity
of diamond.

Carbonic acid + is not generally a supporter of combustion, but if
Potassium is heated in it, it burns with a white intense heat.
The constitution of the gas is thus proved, as charcoal in fine
powder is deposited, the gas disappears, & oxygene is found
added to the potassium.

If a piece of well burnt dry charcoal be introduced into a
vessel, two thirds filled with oxygene gas over mercury; there will
be at first an expansion, but after the experiment is over, it will
be found that the volume of gas is not altered; & if the
charcoal has been in sufficient quantity, the whole of the
oxygene will be converted into carbonic acid; nor the

+ Carbon & Oxygen have so strong an attraction for each other, that Car-
-bonic acid can only be decomposed by substances having a yet stronger
attraction for the oxigen, such as Phosphorus or Potassium. In this manner
other cases oxigen is seen alternately producing acid & alkali

densities of Oxygene gas & carbonic acid gas, in whatever way they are formed, are always the same; & to each other as 34 is to 47 nearly. it is evident then, that carbonic acid must always contain the same weight of oxygene & charcoal. & there is twice as much oxygene in the vessel as is necessary for the combustion of the charcoal, half of it remains untouched; & the charcoal is partly unconsumed, while the gas is the same in quality; it contains by weight 5.7 of carbon & 15 of Oxygene

Carbon Oxe

5.7	15
	7.5

its representative number is Ranfore 20.7.

No compound of Carbon & Chlorine have been as yet discovered; they have no action on each other under any circumstances to which they have been exposed.

~~Carbon & Hydrogen have no known action on each other.~~

Iodine exerts no action on Carbon or Carbonic acid.

The Chlorine does not combine immediately with Carbon, yet a mixture of equal volumes of Chlorine & Carbonic oxide gases, both dried by fused muriate of lime & exposed to bright sunshine, afford a peculiar compound called Phosgene Gas, a substance of little importance The colour of the Chlorine is destroyed by this combination, & the constituent gases are condensed into half their bulk. Lavoisier appears to be the nearest gas known, 100 cubic inches being estimated to weigh 105.91 grains.

Carbon does not combine with Phosphorus.

This gas has a very pungent but not disagreeable odour, &
reddens litmus, whence it is called by some chemists Rhogenic acid.

of Carbonate of Ammonia.

When Ammoniacal gas & Carbonic acid gas are mixed together
one measure in the proportion of one measure of Carbonic acid
to two of Ammoniacal gas, they both quit the state of gas, &
are entirely condensed into a white solid saline body, called

Sub-carbonate of Ammonia

It converts vegetable blues to green as the pure alkalies do.

The Bi-carbonate of Ammonia consists of equal measures
of the two gases

+ These gases readily combine + produce one of the most useful + best known of the ammoniacal compounds. It may also be formed by pouring a little liquid ammonia into a vessel containing carbonic acid.
It consists of one of carbonic acid = 20·7 + one of Ammonia = 16 its weight therefore is 36·7.
If carbonate of Lime + Muriate of Ammonia be sublimed, a sublimate of carbonate of Ammonia is produced, + Muriate of Lime is left in the retort.
If it be thrown into any dilute acid, it dissolves with considerable effervescence, carbonic acid flies off, + the other acid combines with the Ammonia.

+ It is formed by the decomposition of the alcohol which contains its elements.

+ In this process the gases act slowly upon each other, & the only substance formed commonly called Chloric ether, being a compound of Chlorine, Carbon & Hydrogen.

Lecture 25th

of the Compounds of Carbon with Hydrogen.

There are two compounds of Carbon & Hydrogene, which are perfectly distinct & well characterized bodies. the one is composed of one proportion of Carbon & one of Hydrogene; & the other of one of Carbon & two of Hydrogene.

The first is called heavy carburetted Hydrogene, super-carburetted Hydrogene, or Olefiant gas, 100 cubical inches of it weigh 30·15 grains; its specific gravity is 9 that of hydrogene as 13·4 is to one; To obtain this gas a mixture of four parts by weight of Sulphuric acid, & one part of strong spirits of wine or alcohol is heated in a retort; the gas may be collected over water, & is found to be a peculiar gaseous compound of Carbon & Hydrogen.

It burns with a beautiful white flame, much more intense than that of any other inflammable gas; it neither supports combustion nor is fit for respiration.

When it is mixed with any equal volume of Chlorine, the two gases condense each other, & a peculiar fluid is formed of an oily substance, compound of Carbon, hydrogene, & Chlorine, & from this circumstance this species of Carburetted hydrogene is called Olefiant gas.

If the mixture of this gas & Chlorine be inflamed, the two

gases are immediately decomposed; the Carbon is precipitated in a very thick black vapour which flies off, & Muriatic acid is formed, by the Chlorine combining with the hydrogen.

If this gas be burnt with Oxygene; water & Carbonic acid is produced, from the decomposition; that is a proportion of the oxygen unites with the proportion of the carbon to produce carbonic acid, & the remainder of the oxygene unites with the hydrogen & forms water.

One volume of this gas requires three volumes of Oxygene for its combustion; water & about two volumes of carbonic acid are formed in this process.

It has been proved by experiments of this nature, that this Olifiant gas is compound of one proportion of Carbon (5·7) & one of Hydrogene (1) Thus

Carbon	Hyd
5·7	1

its Number is 6·7.

The decomposition of Olifiant gas when burnt with three proportions of Oxygene, to form water & Carbonic acid is thus represented.

Olefiant gas.	Oxyg.
6·7	7·5
	7·5
	7·5

One proportion of the Oxygene (7·5) combines with one of Hydrogen (1) to form water (8·5) & the other two proportions of the

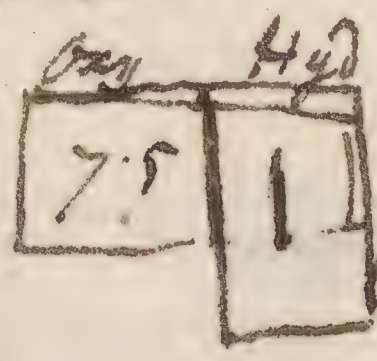
+ Thus Oleiferous Chlorine

Carbon	5·7	1	Hyl	mixed with one of Chlorine	33·5

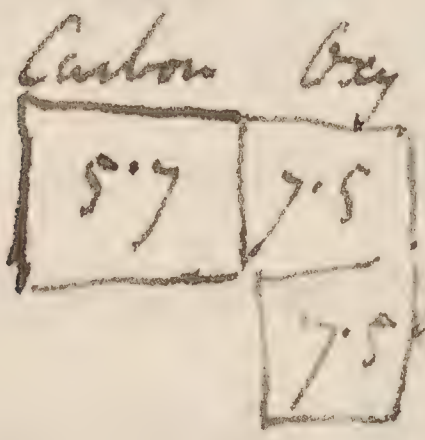
The Chlorine forms no combination with the carbon, but combines immediately at a high temperature, as by heating, & forms, with the one proportional of Hydrogen, Muriatic acid, & the Carbon is thrown down, or rather rises in a thick black vapour

+ But from experiments since made, it is rather supposed at
to be a definite compound, but only an indefinite mixture.

Oxygene (15) combine with the one of Carbon (5·7.) to form the Carbonic acid.



forms Water



forms Carbonic Acid

Of light Carburetted Hydrogene Gas.

This other variety of Carburetted hydrogene, is disengaged in certain natural operations, particularly during the decomposition of animal & vegetable substances (which contain its elements) it is the gas evolved in stagnant waters

It may be procured purest by distilling moist charcoal in iron retort at a red heat, & then well washed with lime water to deprive it of its carbonic acid.

It may also be procured by the distillation of coal that burns with flame, & by decomposing Acetite of Potash by a red heat.

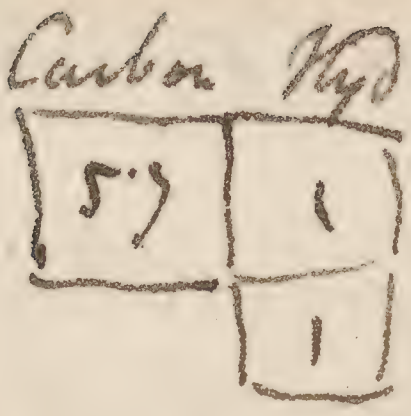
It burns, when pure, with a flame like hydrogene, & requires twice its volume of Oxygene for its combustion.

It is much lighter than the other species of Carburetted Hyd^e 100 cubical inches of it weigh 17·32 grains, its Specific gravity is to that of hydrogene as 7·7 to 1. & to air as ·573 to 1000.

when burnt with two proportions of Oxygene, it is decompound & produces water & Carbonic Acid.

+

And from experiments of this nature it is proved to consist of one proportion of Carbon (5·7) & 2 of Hydrogene) 2(.

Thus 

its representative number is therefore 7·7

The fire damp of coal mines has been shown to be identical in composition with light carburetted hydrogene gas, it therefore when exploded in contact with common air is extreamly explosive & dangerous.

Sir H Davy has invented a lamp upon the most simple construction to obviate the danger: he ascertained that if the flame of this gas be surrounded with a very fine wire gauze, it could not penetrate or mix with the surrounding air, owing to the cooling influence of the gauze, so that when any of this gas was formed in the mine, it could only take fire within the gauze, burning with a whitish flame without explosion, & thus warning the miners of its presence, without being able ~~to~~ to pass outwards in the inflamed state, or mix with the surrounding air.

Pit coal furnishes this gas in great abundance, tho' not pure, & is in this way procured for the gas lights now in use.

It is a most useful & economical process, which at the same time produces substances such gas, coak, tar, & ammoniacal liquor, which altogether are of considerable more value than the price of the coal consumed.

+ The varieties of Carburetted Hydrogen are abundantly produced during the destruction distillation of pit coal

The coal is placed in oblong cast iron cylinders or retorts, which are ranged in furnaces, to keep them at a red heat, & all the volatile products are conveyed by a common tube into a condensing vessel kept cold by immersion in water, & in which water, tar, ammoniacal & other condensible vapours, are retained; the gaseous products consist principally of a mixture of carburetted hydrogen, sulphuretted hydrogen, & carbonic oxide & acid: these are passed thro' a mixture of quick-lime & water, in vessels called purifiers, by which the sulphuretted hydrogen & carbonic gases are absorbed, & the carburetted hydrogen gases, transmitted not quite pure from sulphur, but sufficiently so for use into gasometers, whence the pipes issue for the supply of streets & houses &c the coke remaining in the retorts is of a very good quality

The best kind of coal for distillation is that which contains most bitumen & least sulphur. The chaldron should yield about 12000 cubical feet of purified gas, of which each burner equal to six wax candles, may be considered as consuming from four to five cubical feet per hour.

The economy of gas illumination may be judged of by examining the value of the products of distillation of a chaldron of coals, the average cost of which may be considered as £3. it should afford

		£	s	d
1¼	Chaldron of Coke at 30	1	17	6
24	Gallons of Tar & Ammoniacal liquor at 3d	0	6	-
12000	Cubic feet of gas at 5s per 1000	3	0	0
		£ 11	3	6

These products are taken at a low value, but they afford ample grounds for showing the advantage of gas illumination

It would appear from the above estimate that the gas companies would gain above £8 upon every chaldron of coals, but when the expence of building & repairing their factories is taken into the

consideration, their dimensions are not so large as has been estimated.

The apparatus for procuring the gas from oil consists of a furnace with a contorted iron tube passing thro' it, into which, when red hot, the oil is suffered to drop: it is decomposed & converted entirely into charcoal, which is deposited in the tube, & into carburetted hydrogen of which from two or three cubic feet may be regarded as equivalent to a foot of coal gas, for the production of light; added to which it has the advantage of containing no sulphur.

It has however its disadvantages, from the nature of the coal which is often employed, as this substance generally contains a quantity of sulphur, which on burning produces sulphurous acid gas, occasioning a disagreable smell, & often clogging the copper pipes with the Sulphuret of copper which is formed during the combustion.

In the manufacture of this gas, it is much purified by washing & being made to pass frequently thro' lime water, by which means many of its volatile impurities are condensed, tho' it is seldom entirely freed from them.

It is now procured with much additional advantage from oil, in larger quantities & more pure. Bad oil unfit for other purposes will produce good gas, & the gasometer, for this purpose need not be so large as those for distilling coal.

Of Cyanogen or the Compound of Carbon with Nitrogen

Cyanogen is a gas compounded of Carbon & Nitrogen, burning with a purple flame, from whence it derives its name. its smell is strong & penetrating. 100 cubic inches of it weigh 54 grains, its specific gravity is to that of Nitrogene as 24 is to one. to atmospheric air as 1·8064 to 1000.

It is procured by distilling pure Prussiate of Mercury in

small quantities; the salt first blackens, then liquifies, the Cyanogen comes over in the form of a gas, which must be collected over mercury, as water absorbs it.

When detonated with Oxygene it is decomposed & produces Carbonic acid & Nitrogen, a portion of the Oxygene remaining uncombined if the oxygene is added in too great a proportion.

~~By Analysis~~

By experiments of this nature it is found to consist of two volumes of Carbon (11·4) and one of Nitrogen (13) thus

Carbon	Nit
5·7	13
5·7	

its representative number is 24·4.

Combined with Chlorine it produces Chloro-cyanic or Prussic acid, a colourless liquid, composed of equal volumes of Cyanogen (24·4) & Chlorine. Of this acid more will be noticed hereafter.

Of Sulphuret of Carbon. or Alkohol of Sulphur.

This is a substance composed of a compound of Carbon & Sulphur it is highly inflammable, has an acrid pungent & somewhat aromatic taste; its smell is nauseous, tho' differing from that of

Sulphuretted Hydrogene

Few substances are more important in civilized life than the different forms of Carbon, in their various uses they are essential to the comforts & well being of society

St. phosphus acid prohertii, a reddens vegetable blues.

† This substance is obtained by heating in a copper tube two parts of the metal Potassium with one of Boracic acid (which consists of Boron & Oxigen) previously fused & powdered, & the acid is decompound by the metal which combines with the oxigen of the acid, & liberates the Boron.

Boracic acid is usually obtained by dissolving the salt called Borax (the Borate of Soda) in hot water, & subsequently adding half its weight of sulphuric acid; as the solution cools, white scaly crystals appear, which are nearly tasteless, & which consist of Boracic acid combined with water, which it loses by exposure to a red heat, & fuses into a glassy substance. it is very difficultly soluble in water, & the solution reddens vegetable blues.

& are necessary in almost all the useful arts & manufactures

In nature the carbonaceous element is constantly active
in an important series of operations; it is evolved in fermentation
& combustion, in carbonic acid; it is separated from oxygene
in the organs of plants, is a principal element in animal
structures, & is found in different forms in almost all the
products of organized beings.

Of Boron. +

Of this substance very little is at present known
It is the basis of the boracic acid, & may be procured in very
small quantities pure
It is in the form of a powder of an olive colour, it burns vividly
in oxygen & produces Boracic acid
The + acid combines with alkalies & earths; but the only important
combination which it forms, is with Soda, known in the shops
by the name of Borax.

Lecture the 26th.

Of Metals in general, & their general Properties.

The Metals are generally distinguished by their lustre, opacity, considerable specific gravity (with some exceptions)

They are all good conductors of heat & electricity; they possess different degrees of malleability, ductility, tenacity & fusibility.

To estimate the specific gravity of a metal, it must first be weighed in air, & afterwards in water, in which ascertain how much it loses, then divide its original weight by its loss in water, & we have its specific gravity.

Thus if a certain quantity of Antimony weighs 378 grains in air, & loses 57 grains in water

$$57 \overline{)\,378\,(\,6\cdot 63} \text{ Its specific gravity}$$

342

360

342

180

171

Metals are all more or less combustible & fusible at different temperatures. Some of them may be made to boil, & are actually converted into vapor, at a heat considerably below redness; while others require a very intense heat for their fusion. Potassium melts at 150°, & all may be melted by the effects of Voltaism. Some undergo a change at common temperature of the air; others when heated attract Oxygene from it & become Oxides. Zinc in leaves takes fire at the flame of a lamp, others burn only when submitted to flame under the influence of a stream

+Density is not an essential property of metals, as the specific gravity of Potassium is less than water.

They are all more or less susceptible of crystallization generally, when the crystals are perfect, in the form of a cube or octahedron.

Oxygen combines with all the metals; but with some much more easily than with others. Potassium for instance cannot be exposed to the air without tarnishing or combining with oxygen. Gold & Silver an very difficultly oxidized; Lead & Iron anteriorly oxidized on exposure to the air.

Some metallic Oxides give out oxygen when simply heated; some do not give it out by heat alone, but require to be mixed with some substance having a greater attraction for the oxygen, in order to reduce the oxide to a metallic state.

Some other combine with oxygen in one two, three or more proportions, but these are always multiples of the first.

The different metals attract oxygen with different degrees of force, their oxides differ much in their variety of colour.

Some metals combining with oxygen produce acids, as Arsenic, some in so doing produce alkalies as Potassium Sodium, Calcium &c.

of Oxygene gas, & the fumes are the oxide of the metal submitted to the experiment.

And as the metals have not been decompounded, they may be considered as simple combustible substances.

They have all different attraction powers with regard to Oxygene, hence they may be reduced by each other, & to convert the metals into oxides there is a degree of heat peculiar to each metal.

Some oxides are decomposed by mere exposure to heat, others require the joint agency of some body which has a strong attraction for oxygene, & each metal combines with a certain fixed proportion

In all cases of the combustion of the metals in common air or oxygene gas, oxygene is absorbed, & the metals become heavier in proportion to the oxygene which is taken up in converting them to the state of oxides.

Some oxides are insoluble in water, others are soluble & some, constituting metallic acids; some are soluble & alkaline; & all the oxides of the different metals differ in colour.

All metals that are oxidized by atmospheric air, are still more readily oxidized by oxygen gas; in many cases a metal which undergoes this change slowly & invisibly by the action of air, takes fire in oxygen gas, & exhibits a bright inflammation.

Of these sources of oxygen the most important, if not the only ones, are water, the acids, & the oxides; or compounds containing one or more of these substances

Water gives up its oxygen to those metals only which manifest a powerful affinity for that basis, & generally to those which are most efficient in decomposing atmospheric air. Thus Potassium decomposes it with a rapidity which amount to actual inflammation, but in general, the change is slow at common temperatures. Thus iron filings for example when moistened with water, & confined over mercury become very gradually oxidized, & evolve hydrogen gas; but water brought into contact with red-hot iron, is rapidly decomposed, & hydrogen gas is disengaged in torrents.

Some of the acids which do not in their concentrated state act upon metals, acquire the power of oxidizing them when diluted with water, the hydrogen of the water is evolved, & the oxygen combines with the metals.

Thus from knowing the proportions of these gases constituting water, the oxygen which combines with the metals may be computed, from the quantity of hydrogen evolved, & the most oxidizable metals from which of course produce the

greatest quantity of hydrogene.

Water combines with some metallic oxides, & no metal can become soluble in an acid, till it is first oxidized.

Those acids which part most easily with their oxygene are the most powerful in their effects upon the metals, as the nitric acid; & those which have not been proved to contain oxygene, are remarkably inert in their action on metals; & the same inactivity belongs to those acids, in which the oxygen & base are held combined by a powerful affinity, thus highly concentrated Sulphuric acid scarcely attacks any of the metals (without the addition of water) because the oxygen & sulphur of which it consists, forcibly attract each other.

Thus in this instance water is the source of the oxygen

The same metal in different states may evolve different quantities of hydrogene; in the metallic state it is dissolved with effervescence, always occasioned by the escape of the gas; but in the state of an oxide, it is silently dissolved, without any discharge of gas.

Metals are also oxidized by the transfer of oxygen from other metallic oxides, arising from the different attraction powers of the different metals for this substance.

Besides the class of acids, which are the best solvents of the metals, alkaline solutions act upon metallic substances.

The water which holds the alkali in solution, is decomposed; its hydrogen is disengaged, & oxygen transfered to the metal; & the oxide thus produced is taken up by the alkaline liquor.

The compounds of Ammonia with metallic oxides are called Ammoniurets. they may be formed either by acting on the metals with liquid ammonia, or they may be produced by exposing the oxides to ammoniacal gas at the temperature of the atmosphere.

The Compounds of metals with Hydrogene are neither numerous nor important. when water is decomposed by certain metals, at the same time the oxygene combines with one portion, the hydrogen which is disengaged, takes up a minute quantity of the metal, which is the cause that the gas thus produced is seldom pure, & for accurate experiments must be freed from the metal. this is the case in a small degree with iron, but more particularly with zinc, arsenic & tellurium.

All the metals are susceptable of combination with Chlorine. when exposed to this gas in a state of minute division, they combine with it, for the most part with the appearance of combustion. but some combine with chlorine without the extrication of heat & light.

This combustion therefore takes place without the presence of oxygene, but in consequence of the intensity of chemical union. these compounds are called Chlorides.

Nitric acid acts upon & dissolves the greatest part of the metals; but none can be acted upon by an acid unless oxidized either by the acid itself or by water.

+ Because the attraction of Chlorine for the metals is greater than that of the oxygen for the metals.

Some of the Chlorides of the metals are soluble, others not; some chiefly easily others with difficulty.

They may be often prepared by adding a solution of Chlorine to a solution of the metal, when the Chloride is thrown down.

Chlorine like Oxygen sometimes combines with them in more than one proportion.

Muriatic acid found when many of the metals produces a Chloride; the hydrogen being evolved, the Chlorine combining with the metal, the acid being thus decomposed into its separate elements.

If a solution of Mercury be added to a solution of Iodine an Iodide is thrown down. The same takes place with a solution of Silver.

Carbon combines with one or two of the metals only, Silver is the only one with which it forms a distinct compound.

From the greater number of the metallic oxides, Chlorine expels the whole of the oxygen & takes its place; it combines with the metals in different proportions.

Iodine when heated with the metals, combines with all of them & forms a compound called Iodurets. O

The compounds of the metals with Sulphur are called Sulphurets. all except gold, zinc & tin combine with it. in order to effect their union, it is sufficient that one of the bodies be in a fluid state. in these compounds the properties of the metals cease to be apparent, for the sulphurets are generally brittle & without lustre.

Sulpuretted Hydrogen enters into combination with all the metallic oxides, & precipitates them from their solutions in different colours; hence it is an admirable test for the presence of metals.

The compounds of the metals with Carbon are called Carburets. S

Several metals have an affinity for phosphorus & form compounds called metallic Phosphurets.

The metals are for the most part capable of uniting with each other in a state of fusion, & are then called Alloys, & it is probable, tho' not absolutely proved, that they unite in certain proportions only.

In this combination, the metals undergo a considerable change of properties, & acquire new ones, not observable in the separate metals.

Thus the specific gravity of an alloy is seldom the mean of those of its component parts. The ductility & malleability of metals is generally changed by combination, & for the most part these qualities are impaired. This is very remarkably the case with an alloy of gold & lead; the latter of which even in the minute proportion of half a grain to an ounce of gold, renders the alloy quite destitute of tenacity

The hardness, color & fusibility of the metals are also entirely changed in these ~~Combinations~~ of separate metals; & they are generally rendered more oxidizable.

The Metals at present known are 42 in number, which may be classed under the following heads:

Those which have the highest attraction for oxygene, and absorb it at common temperatures These are seven metals of this class. viz these whose decompose water at common temperatures.

Potassium
Sodium
Lithium
Calcium
Barium
Strontium
Magnesium.

} These Metals are extracted from the Alkalis & Alkaline Earths.

The second class are those which absorb Oxygen at a red heat. & are four in number. viz.

Manganese
Iron
Zinc

Tin
Cadmium.

Copper.
Lead.
Antimony.

The third Class are those which do not decompose water at a red heat, & are ten in number viz

Copper
Lead
Antimony
Bismuth
Cobalt

Uranium
Titanium
Cerium
Tellurium
Selenium.

The fourth class are the acidifiable metals, or those that acquire acid properties on combining with Oxygen. there are five in number. viz

Arsenic
Molybdenum
Chromium

Tungsten
Columbium.

The fifth class are those which have a very feeble attraction for oxygen, & are 9 in number, viz

Nickel
Mercury
Osmium
Iridium
Rhodium

Palladium
Silver
Gold
Platinum.

The last class are placed among the metals, more from analogy than from experiment, therefore little is known

ftheir properties. There are six in number viz

Silicum	Zirconium	Yttrium
Aluminum	Glucinum	Thorinum

These last used to be classed among the earths, but modern Chemistry supposes them to be metallic bases combined with Oxygen.

These Notes chiefly to Potassium in the following Pages.

⊖ It is particularly characterized for its strong attraction for Oxygen & Chlorine, & is thereforc capable of decomposing other oxides & chlorides & reducing them to the metallic state, is therefore a very useful substance to the analytical chemist.

⊖ So strong indeed is the affinity of Potassium for Oxygene, that it discovers & decomposes the smalle quantities of water contained in alcohol & ether, even when carefully purified, & disengages from both these fluids hydrogen gas.

Or Naphtha colourless & recently distilled, Potassium has very little power of action; but in naphtha which has been exposed to the air, it soon oxidates, & alkali is formed, which unites with the naphtha into a brown soap, that collects round the globules.

+ Ih attraction for Chlorine is still stronger. a Potassium heated in chlorine will become a Chloride, & the Oxygen will be evolved.

† Because Naptha contains no oxygen, consisting only of
hydrogen & Carbon.

Lecture 29th

Of Potassium, & its Combinations.

Potassium is the metallic base of Potassia, commonly called Potash or the vegetable alkali: to form Potassium, Potash is a thin piece is placed between two discs of platina connected with the extremities of a voltaic apparatus of great power; it will soon undergo fusion, oxygene will separate at the positive surface, & small metallic globules will appear at the negative surface, which consist of Potassium.

It may be procured by chemical means without electricity; if iron filings be heated to whiteness in a curved gun-barrel, & potash be melted & made slowly to come in contact with the turnings, air being excluded, Potassium will be formed, & may be collected in a cool part of the tube

Potassium is possessed of very extraordinary properties; it is lighter than water; its Specific gravity is between 0 & 9 water being 10. it is solid at common temperatures; it is soft of the consistency of wax. it fuses at about 150° & rises into vapor at a red heat, & at 32 becomes a hard solid. it is perfectly opaque & of a white colour resembling a metallic lustre like silver when it is newly cut, but it rapidly tarnishes or becomes oxidized in the air, & to be preserved from change must be kept under ⊕ Naphtha. it is a conductor of electricity. when thrown into water it decomposes it, burning with great violence, & hydrogen is evolved. when the products

are collected in a glass tube under water, free from the admission of air, it does not then inflame, but a considerable quantity of hydrogen is formed, & the water becomes impregnated with a solution of Oxide of Potassium, & is highly alkaline.

The Hydrogen evolved in this experiment is an indication of the oxygene absorbed; for as it is known that 100 parts of Potassium decomposing water, absorb about 20 of Oxygen then

Ox P O
20 : 100 :: 7·5 : 37·5 Number representing the Proportion of Potassium

Therefore 37·5 is its representative number.

It inflames when gently heated in air ~~or Oxygen Gas~~ burns with a red light, & throws off fumes, which are alkaline, & for each proportion of it that it burns, one proportion of oxygene is consumed, therefore this oxide is thus represented $37{\cdot}5 + 7{\cdot}5 = 45$ its representative number.

Potash or Potassa is generally combined with water, & in this state is called Hydrat of Potassa; it consists of one proportion of Potassa $37{\cdot}5 + 7{\cdot}5 = 45$ and one proportion of water 8·5, therefore its representative number is 53·5. and this is the caustic Alkali.

When Potassium is burnt in Oxygene gas, it absorbs a much larger proportion of Oxygene, & burns with intense heat, producing what is called the peroxide of Potassium. This substance consists of one proportion of Potassa 37·5, & three of Oxygen 22·5 therefore its representative number is 60.

& If Turmeric paper be dipped into it, it is immediately turned brown, & rendered the solution to be alkaline.

When water is made to act on Potassium, atmospheric air being excluded, there is much heat & rain, but no luminous appearance

+ It may be freed from its water of combination by the action of even a high temperature.

o It burns with a purple flame, & forms an orange coloured oxide.

+ The peroxide of Potassium, when put into water, effervesces, oxygen is given out, & a solution of the hydrated protoxide is obtained.

† The last process consists in boiling in a clean iron vessel, subcarbonate of potassa, with its weight of pure quick lime, in water. The ley is strained thro' clean linen, concentrated by evaporation, again strained, & set by in a well stopped bottle till it admits of being decanted clear from the sediment. The clear solution is to be evaporated to dryness; in this state it is used as a caustic by surgeons; but it may be further purified by the action of alcohol, which dissolves the pure hydrate, leaves earthy & other impurities; the alkohol is then drawn off by heat.

† If Potassium be heated in Muriatic acid gas, the Chloride of potassium is also produced, the hydrogen of the acid is evolved & remains in the retort.

Pure Potash is prepared by acting upon the Carbonate of Potash by mixing quick lime in its solution, which frees it from ith' carbonic acid; the liquid alkali is then strained, filtered & boiled to dryness. it is then dissolved in alcohol, & upon evaporation, the Potash will shoot into crystals.

This alkali quickly deliquesces or attract moisture very quickly from the atmosphere; it is very soluble, but not volatized by a moderate heat, therefore called fixed Alkali. when melted with silex it forms glass.

Of the Chloride of Potassium

Alone acts very strongly upon this metal, which when gently heated in it, burns spontaneously with a vivid light, and the chloride of Potassium (improperly called Muriate of Potash) is the result.

The attraction of Chlorine for Potassium is much stronger than the attraction of Oxygen; ith oxides are decompos'd by Chlorine, which combines with the metal, & the oxygen is set free, & by this means this gas is procured in the purest state.

This compound of one proportion of Chlorine (33·5) & one of Potassium (39·5) is representativ number is therefore 71.

Chloric acid acts upon Potassium, & produces the Chlorates, which are considered as triple compounds of one proportion of Chlorine (33·5) one proportion of Potassium (39·5) and three proportions of Oxygen (45) therefore the number of it is 116.

This salt exerts powerful effects on inflammable bodies; it detonates loudly when triturated with sulphur in a mortar. it produces similar effects when mixed with powdered charcoal.

If a small quantity of sugar with half its weight of this salt be mixed together, & a little sulphuric acid poured upon it, a sudden & vehement inflammation will be produced ⊕

Phosphorus may also be inflamed under water by means of this salt. put into a wine glass one part of Phosphorus with two of the salt, fill it nearly with water, & down in by means of a glass tube, reaching to the bottom, three or four parts of Sulphuric acid, the phosphorus will burn vividly. +

⊕ a mixture of this kind is the basis of the matches now generally used for procuring instantaneous light, by dipping them in Sul Acid. The inflammation in these cases is caused by the very rapid decomposition of the salt, & the oxygen it contains.

Iodine likewise combines with Potassium, & forms a salt called Hydriodate of Potash, it forms a good test for the presence of metals

Potassium likewise combines with hydrogen, but of this little is at present known.

Of Nitrate of Potash. +

Nitrate of Potash or common Saltpetre is produced abundantly in nature; is formed in nitre beds in the East Indies; when first

Chlorate of Potassa is formed by passing Chlorine thro' a solution of potassa. Chloride of Potassium is formed as one of the results; the other is a salt called the Chlorate of Potassa. It consists of one proportional of Chloric acid & one of Potassa, with ultimate component parts as

Chlorate of Potassa { 6 Prop^{ls} of Oxygen, 5 in the acid, 1 in the chloride } = 45
One Proportional of Chlorine . . = 33·5
One Do of Potassium . . = 37·5
116 Ib Number.

In consequence of the quantity of oxygen it contains, it affords the readiest, tho' not the cheapest means, of procuring Oxygen.

+ This is in consequence of the evolution of Euchlorine

Oxychlorate of Potassa may be formed by moistening one part of Chlorate of Potassa with three of Sulphuric acid, & subsequently heating the mass till it becomes white

It may be decomposed by exposure to a temperature of 412°. Oxygen is given off, & Chloride of Potassium remains in the retort. This salt is found to contain one proportional of oxy-chloric acid = 86
+ one proportional of Potassa = 45 (its number therefore is
= 131.

+ It is formed artificially in Saltpetry & France in nitre beds, by a process which consists in lixiviating old plaster rubbish, which when rich in nitre, affords about 6 per cent. of animal & vegetable matter which has putrified in contact with calcareous earth & impure Nitrate of Lime, which affords nitre by mixture with Subcarbonate of Potassa.

+
Or its ultimate Elements are

6 Prop^n of Oxygen & in the Acid & one in the Alkali } = 45

One Prop^n of Nitrogen = 13·5

One Do of Potassium = 37·5

95

° But when exposed to a white heat, it is decomposed into Oxygen Nitrogen & Potassa

When Phosphorus is thrown upon Nitre & inflamed, a vivid combustion ensues, & the Phosphate of Potassa is formed, a substance of no great importance.

A mixture of 3 parts of Nitre, 2 of subcarbonate of Potassa, & one of Sulphur forms fulminating powder, & explodes with violence in consequence of the rapid action of the sulphur upon the Nitre

Sunpowder consists of a very intimate mixture of Nitre, Sulphur & Charcoal, in different proportions for different purposes. The quickest & strongest powder contains 78 Nitre. 12 Charcoal, & 10 Sulphur. miners powder that which is not required to be very quick, contains a smaller proportion of Nitre.

So that the effects of Nitrate of Potassa or Nitre with combustibles are similar to those of Chlorate of Potassa, tho' not so dangerous violent or rapid.

brought from thence it is an impure salt containing a considerable quantity of muriate of soda. for the purposes of Chemistry it must be purified by solution in water & re-crystallization; & it then obtains the name of refined nitre.

It consists of one part of nitric acid (50·5) & one of Potash (45) or of six proportions of Oxygen (45) one proportion of Potassium (39·5) & one of Nitrogen (13) Therefore its representative number is

95·5.

By the application of a moderate heat it fuses, & being cast into moulds, forms what is called Sal prunelle

Nitrate of Potash is rapidly decomposed by charcoal at a high temperature, & when these substances are mixed with Sulphur they form gunpowder, the result of the combustion of which are Carbonic oxide & acid, Nitrogen, Sulphurous ~~acid~~ Acid of Potash, & the solid residue consists of Subcarbonate, Sulphate & Sulphuret of Potash & Charcoal.

The effects of gunpowder are owing to the rapid combustion of inflammable bodies (the Sulphur & Charcoal) in the oxygen of the Nitre, & the quantity of elastic gas evolved.

Lecture 28th

Compounds of Potassium continued, & of Sodium & Compounds

The Nitrate of Potassa may be procured by saturating nitric acid with Potassa, either in a pure or carbonated state: the solution on evaporation yields crystals of Nitrate of Potassa, or Nitre.

If acid be applied, nitrate of Potassa is decomposed in consequence of the destruction of its acid, & oxygen gas is evolved.

It is composed of one proportion of ~~Nitric acid~~ (50·5) & one of Potassa (95·5) its number therefore is 95·5.

Its great power in supporting combustion depends upon the great quantity of oxygen it contains in a small space; the acid when decomposed, its oxygen is transferred to the combustible & nitrogen or nitrous gas is evolved.

The products of the combustion of nitre & charcoal at a high temperature, are carbonic acid, & nitrogen gases, part of the carbonic acid also remains attached to the residuary alkali & may be obtained from it on adding a stronger acid.

Sulphur also decomposes nitre at a high temperature, & combines with the oxygen of the nitre & produces explosion.

By these reactions in due proportions gunpowder is formed, which at a high temperature, gives rise to a sudden evolution of gaseous matter, which causes its power.

+ Potassium & Sulphur act upon each other very energetically, accompanied with much light & heat, & produce a grey compound which when dissolved & acted upon by water, produces sulphuretted hydrogen. It consists of 37·5 Potassium + 15 Sulphur = 52·5.

Potassa & Sulphur when fused together form a reddish Sulphuret of Potassa (Liver of Sulphur) this deliquesces very soluble in water forming a yellow solution of Hydrosulphuret of Potassa. The action of the Sulphuret of Potassa on water is complicated, what

been variously explained; but it appears most probable, that when Sulphur & the alkalies are fused together at a high temperature, the latter undergo decomposition, & that Sulphurets of their metallic bases are actually formed.

+ This salt is called Sal de duobus by the old Chemists, but is the least useful of the aforesaid salts in consequence of its difficult fusibility.

The Subcarbonate of Potassa is also sometimes called Salt of Tartar because it is often obtained from the burnt lees of wine. It is fusible without decomposition, at a red heat; is very soluble, & deliquesces by exposure to air, forming a dense solution called oil of Tartar per deliquium.

The Subcarbonate of Potassa is a salt of great importance in many arts & manufactures, & is known in commerce in different states of purity, under the names of wood-ash, pot-ash, & pearl-ash. It may be obtained directly by passing carbonic acid into a solution of potassa, evaporating to dryness, & exposing the dry mass to a red heat.

The carbonate of Potash or Potash of commerce is obtained by burning wood & contains a variety of impurities which render it of variable value. in general its purity may be judged of by its easy solubility in water, two parts of which should entirely dissolve one part of the salt; the residue, if any, consists of impurities.

+ They produce a precipitate in Muriate of Platinum, which is a triple compound of potassa, oxide of Platinum & Muriatic acid. They are not changed by sulphuretted hydrogen, save by the ferro-prussiate of Potassa.

And this gaseous matter consists of Carbonic acid, carbonic oxyde, & nitrogen, & sulphuretted hydrogen.

Of the Sulphates of Potassa. +

This salt may be procured by saturating the carbonate of Potassa with Sulphuric acid, & crystallizing the solution.

It is composed of one proportion of acid & one of Potassium, their acid
P
45 + 39.5 = 82.5 its number.

The Sulphite is composed of one of Potassium (39.5) & one of Sulphurous acid (30) its number therefore is 69.5.

The Bisulphate is composed of two parts of its base (75) & one of acid (45) therefore its representation number is 120.

The Phosphates are composed of Phosphoric acid & Potassa, & are of little importance.

Of the Carbonate of Potassa. O

Carbonic acid is very abundantly absorbed by a solution of pure potash, & has a very strong affinity for it.

The Sub-carbonate is composed of one proportion of Carbonic acid (20.7) & one of Potassa (45) its number being 65.7

This salt is very soluble in water, & when exposed to the atmosphere rapidly deliquesces.

The Bi-carbonate of Potash is composed of ~~the~~ parts of Potash (45) & two of acid (41.4) its ~~number being~~ & one of water (0.5) its number is therefore 94.9

All the salts of Potash are soluble in water, & afford no precipitate with pure or carbonated alkalies. +

The Bi-carbonate differs from the Sub-carbonate, in being milder in its taste, tho' like the alkaline, it is unchanged by exposure to air. by calcination at a low red heat, a portion of its acid is driven off, & it becomes a sub-carbonate.

Of Sodium.

Sodium may be obtained from Soda exactly in the same manner as Potassium from Potash. its number is represented by 22.
It resembles Potassium in most most of its characters, is rather harder in its texture, & when thrown upon water, effervesces violently, but does not inflame, swims about on the surface, gradually diminishing with great agitation, & renders the water alkaline from a solution of soda. it acts upon most substances in a manner similar to Potassium, but with less energy.

Of Soda.

It forms two distinct definite combinations with oxygen: one is pure soda, combined with water, & is composed of one part of Sodium (22) & one of oxygen (7·5) with one of water (8·5) its number is therefore 38.* the second compound is formed with two parts of oxygen. * when pure from water Soda is represented by 29·5.
The other combinations of Soda are of little importance except in medicine. the Chloride of Soda is common salt. Sulphate of Soda is the Glauber salt.
To distinguish the two alkaline solutions, mix them with tartaric acid, & a gritty powder will be deposited in the solution of Potash.
The other remaining class.

+ The Bi-carbonate is formed by passing a current of carbonic acid into a solution of the sub-carbonate. by evaporation crystals are obtained.

Both these Carbonates are decomposed by lime, which destroys them of carbonic acid; hence the use of that earth in the process for obtaining pure potassa.

+ Soda as it usually occurs in the Laboratories, is obtained from the subcarbonate by the action of lime which takes from it its carbonic acid. It is distinguished from Potash by efflorescing when exposed to air, whereas that is distinguished by deliquescence. If excess of tartaric acid be added to a solution of both deliquescences. if excess of tartaric acid be added to a solution of soda, there is no precipitation, but crystals are deposited in a solution of potash with excess of tartaric acid. solution of Soda occasions no precipitate when added to a solution of Muriate of Platinum. solution of Potassa occasions a yellow precipitate in solution of Platinum.

The Chloride of Sodium or common Salt, consists of one proportion of Chlorine 35·5 + one of Sodium = 22 its number therefore is 55·5

It is equally soluble in cold as in hot water, a curious exception to the general properties of saline bodies

Its composition may be known by the direct union of soda with muriatic acid. it is found abundantly in nature, often tainted with oxide of iron, a certain other salts which are deliquescent, causing it often to appear moist in damp weather.

Sulphate of Soda (Glauber Salts) is abundantly produced in the manufacture of muriatic acid, by the action of sulphuric acid upon common salt.

Subcarbonate of Soda is chiefly obtained by the combustion of marine plants, the ashes of which afford, by lixiviation, the impure

alkali called barilla, kelp, or soda, in Not State it is mixed with common salt & other impurities, from which it may be separated by solution in a small portion of water, filtration, & evaporating it at a low heat. The common salt may be skimmed off as its crystals form upon the surface. This carbonate contains seven proportionals of water which may be expelled by heat, they effloresce by exposure to the air.

The Salts of Sodium are soluble in water; they are not precipitated either by pure or carbonated alkalies, or hydro-sulphuret of ammonia, or pure muriate of Platina, & produce no precipitate in solutions of Muriate of Platinum.

Of Lithium & Calcium, & Lime.

Lithia has been very lately discovered in a mineral called Petalite found in Sweden. about 3 per cent of an alkaline substance was discovered in it, which was at first supposed to be Soda. but on more accurate examination. this new substance displayed properties entirely distinct from Soda or Potassa, especially that of neutralizing a much greater quantity of the different acids than either of these alkalies, to which respect it even surpassed Magnesia. The metallic base is represented by the number = 9.

It has also been discovered in a mineral called Lepidolite.

It has all the alkaline properties, has an acrid, caustic taste, & like them changes vegetable blues to green.

Lithium, its metallic base, has been formed from Lithia, in the same manner as Potassium from Potassa, but it has been obtained in such small quantities & burns again so rapidly that its properties have not been clearly ascertained.

Yet its properties are but little known, & have been applied to no useful purpose.

Of Calcium.

Calcium is the metallic basis of quick Lime procured in very small quantities by means of decomposition by Voltaic electricity. From the small quantity produced, the chemical & general qualities of this basis are unknown; but its compounds form important

natural products. the number representing Calcium is 19.
Of Lime

There appears to be only one compound of Calcium & Oxygen, viz Lime, composed of one of Calcium (19) & one of Oxygen (7·5) its number is therefore 26·5.

Lime is obtained for ~~accurate~~ purposes from marble of the whitest kind, by long exposure to a strong heat; it is also procured in the same manner from all the Carbonates of Lime, such as chalk, by driving off its carbonic acid by means of heat.

It is a ~~grey~~ soft substance, its Specific gravity is 2·3 & requires a very intense heat for its fusion, & it is not volatile. it acts upon vegetable colours in a manner similar to the other alkalies

earths; when exposed to the air it becomes white by the absorption of water & a little carbonic acid
When water is poured upon quick Lime a considerable degree of heat is produced, & the water becomes consolidated in the Lime, which now becomes a Hydrate, consisting of one proportion of water (8·5) & one of Lime (26·5) the number of the hydrate therefore is 35

Lime is very sparingly soluble in water in the proportion of about 1 to 450 parts when thus dissolved is called lime-water, which acts strongly upon vegetable colours, proving its basic alkaline powers. when exposed to the air, lime is incrustated from it in the state of a Carbonate, having attracted Carbonic acid from the air of the atmosphere.

Lime obtained in the common way for the purpose of building
is not pure

+ Thus lime water poured upon vegetable blues turns them green
& the yellows, red.

Lime water is usually prepared by pouring warm water
upon powdered lime, & allowing the mixture to cool in a close
vessel, the clear part is then decanted off from the remaining
undissolved portion of lime.

† Oxelate of Ammonia is a Sple more delicate test for Lime.

† Vide Lime is exposed to Chlorine at a high temperature
it undergoes the same changes as the other alkalies.
The Chloride of Lime consists of one proportional of Calcium = 19
& one of Chlorine = 33·5 ich number therefore is 52·5.

† Vide Nitrate of Potassa

† The Nitrate of Lime is of use only as the principle source
of Nitre. it is found in old plaster & mortar of houses or the
places where animal substances have putrefied; the nitrogen
of the animal substance uniting to the oxygen of the air & from
the Nitric acid, which unites to the Lime & forms Nitrate of Lime.
from the washings of this substance Nitre is procured by
the addition of Subcarbonate of Potassa. a double decomposition
takes place, & a uniting to the Potassa, the CA
to the Lime.

If Lime is exposed to the mixed with water it is easily detected by mixing with it a little carbonic + acid which immediately causes a precipitate. it is even detected by breathing into it, from the carbonic acid produced by respiration.

Of Chloride or Muriate of Lime. +

When Lime is heated strongly in contact with Chlorine, its oxygen is expelled & chlorine absorbed.

It is very soluble in water, deliquesces rapidly in the air, & enters into fusion when heated. when dried & fused it has a very strong attraction for water & moist vapours, & in a pulverulent state is much used in the laboratory for drying gases by freeing them from moisture; it also produces intense cold in melting, & is used for freezing mixtures, on account of its very rapid liquefaction.

When in a state of Hydrate it becomes what is sometimes called Muriate of Lime. it is much used in Bleaching as it destroys many vegetable colours, without injuring the texture of the cloth

The Nitrates + of Lime is of little importance, as are the Sulphuret.

Of Sulphate of Lime.

This substance is found native in great abundance under the names of Gypsum, Plaster of Paris, Selenite, Satin Stone, Alabaster &c.

It may be formed artificially by adding Sulphuric acid to Lime Carbonate of Lime & calcining the residue to expel the redundancy of the latter acid.

This is composed of one proportion Lime & one of acid. Thus Lime

being 26·5 & Sulphuric acid 37·5 is number is 64.
The Hydrate combines with two proportions of water (17)
& its number therefore is 81.
It is much softer & more easily worked than the Carbonate
& is therefore cut into many ornamental figures by the stationary
& lapidary.

Of Phosphate of Lime

This substance is a very abundant natural product in the
animal vegetable & mineral world, & is the basis of animal
bones.

Of Phosphuret of Lime.

This substance has the remarkable property of decomposing
water at the common temperature of the atmosphere, if a piece
of it be dropped into a glass of water, in a short time bubbles
of phosphorelled Hydrogen gas will be produced, which
igniting at the surface, will take fire & explode spontaneously.
It is composed of one proportion of Lime (26·5) & one of Phosphorus
(26) its number therefore is 52·5.

Spring water in general contains Sulphate of Lime in more or less quantities, which occasions its hardness; whence for the purpose of washing, as it causes the soap to curdle; hence a solution of soap is a good test to ascertain how far the water is fit for such a purpose. but the oxalate of Ammonia will detect the smallest quantity.

If tried upon distilled water, or that procured from the melting of ice or snow, no sulphate of lime is discovered.

When Sulphate of lime is exposed to a violent heat, it loses its water of combination, & falls into a white powder commonly called Plaster of Paris.

as Sulphate of lime is more soluble in pure water than pure lime, Sulphuric acid affords no precipitate when added to lime water.

Native Sulphate of lime occurs in various forms. the crystallized variety is usually called Selenite; the fibrous, earthy, Gypsum. the granular or massive, Alabaster. it is softer than the carbonate of lime, & yields easily to the nail.

† Thi compond of one proportional of lime = 26·5 + one proportional of carbonic acid = 20·7 ih number thereforn i 47·2.

Carbonate of Lime ii precipitald by the carbonated alkalei from solutions of muriate & nitrate of Lime.

† Thi compond of one proportional of lime = 26·5 + one proportional of carbonic acid = 20·7 ih number thereforn i 47·2.

Carbonate of Lime ii precipitald by the carbonated alkalei from solutions of muriate & nitrate of Lime.

† Hence Lime is used in order to procure from Potash or Soda from their carbonates, the carbonic acid uniting to the Lime leave the Potash or Soda in a pure state, & the Lime becomes a Carbonate.

† Excess of Carbonic acid in redissolving the precipitate, produces a super-carbonate.

† The excess of acid which kept the carbonate in solution flies off after having been exposed some time to the air. & the carbonate is then precipitated.

Lecture 30th.

On the Carbonate of Lime. +

The Carbonate of Lime is a very important & abundant natural production. common chalk, lime-stone, marble, marle, & Stalactites are all carbonates of lime.

Lime has a ~~very~~ strong attraction for Carbonic acid, & if lime water be exposed to the air it soon becomes covered with a crust of Carbonate of lime, from the action of the carbonic acid of the air; but if an excess of acid is poured upon it, the precipitate is redissolved

Lime when exposed to the air, first acquires moisture, & then carbonic acid, & in a sufficient space of time, all its characters of lime disappear & it becomes a carbonate. This accounts for mortars becoming hard.

The carbonates of lime are far more numerous than any other substance, they are composed of one proportion of lime & one of acid.

The strong affinity of lime for carbonic acid enables it to take this acid from the other alkaline carbonates. +

The carbonate of lime is decomposed by a strong heat, & by the stronger acids.

when dissolved by an excess of acid, it is again separated when this excess is driven off; thus boiling expells the superabounding acid & reprecipitates the carbonate.

Lime water impregnated with carbonate of Lime. by losing a portion of the acid which holds it in solution, causes the formation of Stalactites & the carbonated crust formed round bodies thrown into the petrifying wells in Derbyshire & other places.

The perfectly white marble is the purest carbonate of lime, the veins are formed by metallic oxides, particularly the oxide of iron.

The soluble salts of lime are not altered by pure Ammonia, but they are precipitated by the carbonate of ammonia.

The insoluble salts of lime are decomposed by boiling them with carbonate of potasse.

The Acetic acid is the best test for the presence of Lime, as it will detect it in the smallest quantities.

Of Fluate of Lime & Fluoric Acid.

Pure Fluoric acid has never yet been obtained in a gaseous state, & its basis unknown.

Fluor spar found abundantly in Derbyshire, is the Fluate of Lime, or the compound of this acid with lime. when this substance is mixed with Sulphuric acid & distilled in a lead or lead retort an intensely active fluid is produced, which corrodes glass & is extremely caustic.

If Fluor spar be mixed with dry boracic acid, & distilled in a vessel with Sulphuric acid, it forms the Fluoboric acid gas which must be collected over mercury.

This gas has a strong affinity for moisture & fumes when in contact with air.

When water is introduced into it, it has the appearance of having been flayed with fire.

The principal use of Lime in agriculture, is fitt to decompose the inert vegetable matter in the soil & render it fit food for the plant; before the plant comes up the caustic Lime attracts carbonic acid from the air & becomes a carbonate, & affords nutriment to the plant.

+ It should be used in the state of Oxalate of Ammonia, & detects Lime in the minutest quantity in Spring water, & the great advantage of Imacceptability with this test is, that the oxalic acid may easily be driven off by heat, & the quantity of pure Lime ascertained.

Fluor Spar is often used as a flux, as it much assists the fusion of bodies.

+ However small a portion of water any gas may contain, a sensible formation of vapour ensues on mixing it with fluoboric acid gas, hence it becomes a very useful test to ascertain if a gas be dry.

+ The fluoboric acid gas has such an eager attraction for water, that if water be introduced into it, this immediately absorbed.

If Ammonia be mixed with it a condensation ensues, & a deposition of a white compound, called the Fluoborate of Ammonia is formed.

+ owing to its great affinity for the hydrogen of the Gases, & the Carbon becomes visible.

O Sts not only a most delicate test for sulphuric acid, & Sulphates but indicates the quantity of sulphuric acid from the weight of these salts, for if we know the weight of a certain portion of S of Baryta & proportions of its combinations, the double rule of three, gives the proportion of any insoluble obtained.

+ Barya is obtained by exposing Nitrate of Baryta to a bright red heat. it consists of 65 Barium + 7.5 Oxy. Atomic wt 72.5

Barium exists in nature in two combinations only viz the sulphate & carbonate of Baria.

The soluble baryte salts furnish white precipitate of carbonate & sulphate of Baria, upon the addition of carbonate & sulphate of Soda. They are poisonous, & give a yellow tinge to the flame of spirit of wine. The sulphate is insoluble in nitric acid & in the alkalies.

The affinity of Baria for Oxygen is less than for Chlorine, so that Chlorine can be made to decompose its oxide.

Strontia exists in nature in the state of sulphate and carbonate.

Of Barium. + or Baria

Barium is the metallic basis of Baryta, & has been obtained only in very minute quantities, its general chemical & physical characters are not ascertained.

5.

+ It combines with one proportion of Oxygen to form Baryta, which was formerly considered as an earth, it eagerly absorbs water like lime, & forms with it a hydrate; it is alkaline ~~then Lime water~~ & is a more delicate test for ~~Lime, than~~ carbonic acid & is a violent poison.

+ It combines also with Chlorine, & is a highly poisonous substance

Baryta has a sharp caustic taste, changes vegetable blues to green, turns as an intermediate between oil & water, & in this respect, bears a strong resemblance to the alkalies.

It combines with the other acids & forms Nitrate, Sulphates, & Carbonates

It is much heavier & harder than carbonate of lime, & Sulphuric acid is the best test to detect its presence.

Strontium. +

Strontium is the metallic basis of Strontia which resembles Baryta in most of its properties.

Its salts are lower ~~more~~ soluble than those of Baryta, & burns in alcohol with a red flame, whereas Baryta burns with a yellow one. Its salts are not poisonous as those of Baryta are.

Strontia is less soluble in water than Baryta.

Lecture 31st.

On Magnesium.

Magnesium is the metallic base of Magnesia, which consists of that metal united to Oxygen. It consists of 11 of Metal & 7·5 of Oxygen, its number therefore is 18·5.

It is procured by driving the carbonic acid from the Carbonate at a red heat. It has little taste or smell, & acts slightly upon vegetable blues, is very infusible & almost insoluble, but does not absorb carbonic acid or moisture so quickly as the other alkaline earths. In the crystallized state it contains water & is called a hydrate of Magnesia.

When strongly heated in contact with Chlorine, the gas is absorbed the oxygen expelled, & it therefore becomes a chloride.

The salts of Magnesia are of little consequence except in medicine, the common Epsom Salt is a Sulphate of Magnesia.

The compounds of Magnesium occur diffused in nature. Magnesia exists in soap stone, asbestos, & in certain lime-stones, which are generally less fitted for the purposes of agriculture manure than common limestone, from which it is known by its having a slight yellow tinge, & being less soluble in acids. It may however be used with advantage in small quantities, when the soil abounds with a superabundance of weak vegetable

&c it is more readily procured in a pure state by precipitating a solution of Sulphate of Magnesia by a solution of caustic Potassa

+ Magnesia when perfectly pure acts very slightly upon vegetable colours, but in its common state often contains a small portion of Lime, which makes the effect more apparent.

Lime, which makes the effect more apparent.

§ To ascertain the Lime formed from Magnesian Limestone is pernicious as a manure; the Lime & magnesia in their caustic state act upon the inert vegetable fibre & decompose it, before that such upon the young plant appears, by which time the Lime has attracted carbonic acid from the air, become a mild carbonate, & improves the soil; but the magnesia from not absorbing the carbonic acid remains caustic & injures the plant.

+ It may be obtained by passing Chlorine over red-hot Magnesia; oxygen is expelled, & a chloride obtained, which moisture converts into a muriate.

The Muriate of Magnesia is found in open saline springs, also in the waters of the ocean

The salts of Magnesia are for the greater part soluble in water, & afford precipitates of Magnesia, & of carbonate of Magnesia, upon the addition of pure soda, & of carbonate of soda. They are not precipitated like the other alkaline salts by carbonate of Ammonia.

+ But this sort of Lime-stone is much esteemed for cements, but it injures plants on account of its retaining caustic for a very long time, in consequence of its not combining so quickly with carbonic acid as the other alkaline earths.

+ The common ore of Manganese is the black or Binoxide which is found native in great abundance.
The metal may be produced by exposing the protoxide mixed with charcoal to an intense heat.

The salts of Manganese containing the protoxide, are mostly soluble in water, & the solution becomes turbid & brown by exposure to air. They are not precipitated by hydriodic acid; they furnish white precipitates with the alkalies, which soon they furnish white precipitates with the alkalies, which soon become discoloured by exposure to air; they are precipitated white by ferro-prussiate of Potash, & yellow by hydro-sulphuret of Ammonia.
The salts containing the deutoxide afford a dirty red precipitate with the alkalies.
The native peroxide of Manganese is used as a source of oxygen

Its number is 53'5.

matter.

Of Manganese. +

This is the first upon the list of the second class of metals. It is seldom found in nature in its pure state, & is difficult of reduction.

When in the pure metallic state, & exposed to the air, it very quickly tarnishes & becomes an oxide, changing its colour in succession from grey, violet, brown & finally black.

There are three different oxides of this metal; the Protoxide being green, is obtained by dissolving manganese in diluted ~~sulphuric acid~~ Muriatic acid & precipitating it by a pure alkali; the Deutoxide being brown which remains after calcining the protoxide; & the Peroxide being black, to which more oxygen cannot be added

When the black oxyde is mixed with muriatic acid; chlorine is evolved; the hydrogen of the acid is attracted by the oxygen of the oxide, & the chlorine is nearly set at liberty.

The metal unites with oxygen in the different proportions of 1, 2, 4.

It forms salts, but of little importance, with many of the acids.

Combined with Nitre

A compound of highly-oxidized manganese ~~with potash~~, dissolved in water has the singular property of exhibiting different colours successively from green to brown & red. This is called the caméleon mineral.

Manganese, is much used in bleaching, glass making, & in chemic manufactories; it is also used for obtaining Oxygen gas & Chlorine. And its Salts are of no inconsiderable use in arts.

Of Iron.

The general properties of this metal are well known.

It is seldom found in a pure state in nature, but generally combined with sulphur, when it is called Pyrites. It is also found combined with acids, & few substances are free from it, it is a component part of animal & vegetable substances, & is found combined with nickel in meteoric stones.

When exposed to the atmosphere, especially when the air is moist, it slowly combines with oxygen, or in common language rusts.

It combines with oxygen in two proportions, forming the black or protoxide, & the red or peroxide of iron.

The first oxide is formed when iron is dissolved in dilute sulphuric acid, or burnt in oxygen gas

When the protoxide is dissolved in nitric acid, & precipitated by ammonia, it is converted into the red ~~oxide~~ brown oxide. This is the peroxide composed of 52 iron + 22.5 Oxygen.

The most important native combinations of iron, from whence the animals supplies for the ash of life are drawn, are the oxides. It is also found in many of the mineral waters.

+ It may be procured by precipitating a solution of sulphate of Iron by potassa, washing the precipitate out of the contact of air, & drying it at a red heat; it is black & consists of 52 iron + 15 oxygen.

The two oxides of iron form distinct salts with the acids

The salts containing the black or protoxide are of a green colour, mostly crystallizable, become reddish brown by exposure to air, & insoluble in alkohol, & their solutions absorb nitric oxide gas & become of a deep olive colour.

The salts with the peroxide do not crystallize; they are brown, soluble in alkohol, & do not absorb nitric oxide.

The alkalies precipitate hydrated oxides from their solutions.

The native oxides of iron constitute a very extensive & important class of metallic ores. They vary in colour, depending upon mere texture in some cases, on others from the substance they may be occasionally mixed with, & against others, upon the degree of oxydegement.

The ores of iron containing the protoxide are generally magnetic.

+ This is far from being the purest iron ore, but is known the chief source of the cast & bar iron, in ordinary use. Its employment is chiefly referable to the coal which accompanies

+ The Sulphuric acid with the protoxide of iron forms a salt, commonly called Copperas or green vitriol, which often prepared by exposing roasted Pyrites to moisture. It consists of one proportional of Protoxide = 69 + two Proportions of acid = 75.

The Persulphate is obtained by dissolving the moist red oxide in dilute Sulphuric acid

Lecture 32

Iron continued.

The oxides of iron are the most important ores of this metal, & the less oxygen they contain the more valuable they are

These ores are all attracted by the magnet, & some of them that are the most pure are themselves magnetic, that is having two poles.

The most pure iron ore is found in Sweden, the micaceous is also a very rich one; the blood stone or hematite found near limestone is also rich & very fibrous; there is also another sort called the clay iron stone very abundant in coal districts, & from being found with coal is the cheapest source of iron in this country.

To reduce the ores the oxygen is expelled from them by roasting them with charcoal or coak; the earthy parts are expelled, by making them in pieces, & exposing them in a kiln to the action of lime-stone which combines with the clay & forms a fusible compound which seperates from the metal.

The representative number of iron is 52.

of Sulphate of Iron. +

Both the oxides of iron are soluble in sulphuric acid, the black produces pale green solutions, & the red deep yellow solutions.

When solutions of these oxides are acted upon by solutions of pure alkalies, a white precipitate, having a tint of green or blue, is thrown down from the solution containing the black

oxide, & an orange coloured precipitate from the solution containing the red oxide, & both these precipitates are the oxides combined with water or Hydrates.

of Chloride of Iron.

There are two compounds of iron & chlorine. the one containing the largest proportion of chlorine is formed by burning iron wire in the gas; this substance is of a yellowish colour brown colour, & is called the Per-chloride.

When the solution of the two chlorides are precipetated by alkalies, one throws down a green, the other a brown precipitate.

Iron also combines with iodine, with the acids, & with Sulphur forming the sulphurets or Pyrites.

Its compounds with carbon produce steel & Plumbago.

of Prussiate of Iron.

Iron may be united in the way of double elective affinity with the Prussic acid. Thus when prussiate of potassa & sulphate of iron both in solution are mixed together, the prussic acid & oxide of iron quit their former combinations & unite together. The beautiful precipitate is prussiate of iron or Prussian blue. The ferro-prussiate of Potassa decomposes all metallic solutions excepting those of Gold, Platina, & a few of the newly discovered metals.

+ The Chloride of iron may be obtained by evaporating green Muriate of iron to dryness & exposing the residuum to a red heat. a grey substance is formed consisting of one proportional of iron 52 + two of Chlorine 67.

The Perchloride consists of one proportional of iron + three of Chlorine.

The Nitrates of iron are of very little importance.

+ The principal use of Pyrites is in the formation of green vitriol or sulphate of iron, for which purpose the ore is gently roasted, exposed to air & moisture.

The Salts of Iron are mostly soluble in water, & the solution is reddish brown, or becomes so by exposure to air. It affords a blue precipitate with ferro-cyanate of potassa, a black precipitate with hydro-sulphuret of ammonia. infusion of gall nuts produces a black or deep purple precipitate

Lecture 33

Iron continued.

The salts of iron are generally soluble in water; they are precipitated from their solutions by the prussiated alkalies, by tincture of galls, & hydrosulphuret.

Iron combines with carbon in various proportions, & becomes cast iron & steel.

Cast or crude iron besides casual impurities, contains oxygen, carbon, & silicium, but its differences depend chiefly on the various proportions of carbon, which is greatest in the grey, or least sort of cast iron, & least in the white variety of cast iron.

When it is refined it is called wrought or bar iron, & is freed from many of its impurities.

When bar iron is long & slowly heated in contact with charcoal it loses oxygen & acquires carbon, & thus becomes steel, which contains a much less quantity of oxygen & earth than common iron. The charcoal which it contains, appears in the form of black stain on applying a drop of any weak acid on its surface.

Tin plate or iron covered with a coat of tin is the only useful alloy of this metal, & of this be washed with any diluted acid, it acquires a beautiful crystalline appearance.

Cast iron is known from wrought iron by its texture, the first

when broke has a crystalline appearance & my brittle, the other is less brittle, & appears composed of a congeries of plates.

Of Zinc. +

Zinc is procured for the purposes of commerce from various ores, called calamine & blend or black jack. The ore is strongly ignited with charcoal, & the zinc which is volatile, rises as a strong red heat, & becomes condensed in the cool part of the furnace or retort.

It is malleable at a temperature of 300°, but brittle when approaching a state of fusion.

There is only one known oxide of zinc, which is obtained by the combustion of zinc in the atmosphere, or by the precipitation of the solutions of zinc in acids by alkalies; when thus precipitated it is in the state of combination with water, & a strong red heat is necessary for its expulsion.

The representative number of zinc is 33.

When zinc is burned in chlorine a solid substance is formed of a shrivel gray colour, which is the Chloride of Zinc.

Of Tin.

Tin is procured from the ores or native oxides of tin by ignition with charcoal.

It is malleable, strongly ductile & very fusible, but requires an intense heat for its vaporization.

+ The Zinc of commerce is never pure, but contains Lead & Sulphur; to purify it, the zinc must be dissolved in dilute Sulphuric acid; a plate of zinc is then to be immersed in the solution, & precipitate the other metals, which it may contain; the solution must be decomposed by Subcarbonate of Potash, & the precipitate cleared by charcoal powder.

The Salts of zinc are mostly soluble in water, the solutions are colourless & transparent. the alkalies produce with them a white precipitate, but they are soluble in excess of alkali or sulphurous acid, therefore care must be taken in Precipitating them with, not to add too much either of the alkali or the acid.

The Carbonate of Zinc occurs native, forming one of the varieties of the mineral called Calamine. it may be formed by adding carbonate of potash to Sulphate of zinc.

Sulphate of zinc is the White vitriol of Commerce.

+ In forming the peroxide of Tin by means of Nitric acid, a violent action takes place, & a portion of ammonia is always formed, in consequence of the decomposition of the acid & of the water

The Salts of Tin are mostly soluble in water. They are precipitated of an orange colour, by hydriodic acid, & by hydrosulphuret of ammonia, hydrated peroxide of Tin by excess of acid be present. Solution of Muriate of Gold & of corrosive sublimate produce purple & black precipitates in the salts of tin containing the protoxide, but none in those containing the peroxide.

There are two definite combinations of tin with oxygen.
The protoxide is gray, the peroxide is white & quite fusa.
It first is formed by heating tin in the air, & by dissolving
tin in muriatic acid, & precipitating the solution whole
recent, by a solution of hydrate of Potassa, or Ammonia.
It is converted into the peroxide by being boiled with nitric
acid, then dried by evaporation & heated to redness.
The oxides are difficultly fusible bodies, insoluble in water,
soluble in diluted sulphuric acid, & in fixed alkaline solutions.
The number representing tin is 58.
It combines also in two proportions with chlorine.
When tin is burnt in chlorine a very volatile clear liquor is
formed, which when mixed with a little water, becomes a
crystalline substance, a true muriate of tin containing the
protoxide. This liquor when exposed to the air emits thick
fumes. It was formerly called Liquor fumans Libavius
The other compound of tin & chlorine is a gray crystalline
substance, & may be procured by heating together an amalgam
of tin & calomel.

Tin also combines with Sulphur & Phosphorus.

The Muriate of tin used by dyers quickly absorbs oxygen from the air, & from
several compounds, & if added to certain metallic solutions, carries off
deoxidizes them; with solution of gold it produces a purple precipitate used
in painting porcelain

Lecture 34

Of Cadmium.

This metal is contained in certain ores of zinc, & especially in the blende of Bohemia.

If Cadmium be present in it, the solution of the ore in muriatic acid affords a bright yellow precipitate with sulphuretted hydrogen.

The properties of Cadmium closely resemble those of tin

The compounds of Cadmium, on account of the scarcity of the metal, have scarcely been examined.

Of Copper

This metal is found native, & in various states of combination.

The metal may be obtained perfectly pure by dissolving copper of commerce in muriatic acid; the solution is diluted, & a plate of iron is immersed upon which the copper is precipitated. it may then be scraped off & fused into a button.

There are two oxides of copper; the red or protoxide occurs native. it may be formed artificially, by dissolving a mixture of metallic copper & peroxide of copper in muriatic acid. when potassa is added, a hydrated protoxide of an orange colour falls: it consists of 60 copper & 7.5 Oxygen.

The Peroxide is procured by precipitating nitrate of copper by potassa, washing the precipitate, & exposing it to a red heat. it is black, & consists of 60 copper & 15 Oxy.

+ The Cadmium may be obtained from it, by digesting the ore in muriatic acid, by which a mixed muriate of zinc & cadmium is obtained. It should be evaporated to dryness, & redissolved in water. if Cadmium be present, the solution affords a bright yellow precipitate with sulphuretted hydrogen, & upon immersing into it a plate of zinc metallic cadmium is precipitated.

~~This metal may now~~

The Copper of commerce always contains a little iron

+It gives to flame almost all the Aromatic colours.

+ Ferro-cyanate of Potassa is also a test for copper, causing a brown precipitate.

+ Ammonia is the best possible test for copper, a little dissolved in the smallest quantities.

If clean copper filings be left some time to digest in Ammonia the liquor is clear out of the contact of air, but when exposed to it, it gradually becomes blue.

all the most essential salts of copper are formed by the peroxide.

Gaseous Chlorine acts upon copper with great energy, & produces two chlorides; the one a fixed fusible substance, which is the chloride containing one proportion of copper & one of Chlorine, & the other a volatile yellow substance, which is a bichloride, containing two of Chlorine.

The bichloride is curious from the colour it gives to flame when burnt in it. The native Chloride is found in Peru.

Nitric acid diluted, rapidly peroxidizes copper, forming a bright blue solution, which affords crystals on evaporation.

Potasse forms in this solution a blue precipitate of hydrated peroxide of copper.

When crystals of nitrate of copper sprinkled with a little water & quickly rolled up in tin foil, great heat produced, nitrous gas is evolved, & the metal often taken fire.

If ammonia be added to a solution of nitrate of copper, it occasions also a precipitate, but if it be added in excess, it is redissolved, & a triple compound produced.

There are two sulphurets of copper, both of which exist native. The copper pyrites is the most important ore of copper from which the copper of commerce is derived

The Sulphate of copper or blue vitriol is formed by dissolving peroxide of copper in sulphuric acid, it crystallizes of a fine blue colour.

If ammonia be cautiously added to this solution, a subsulphate is precipitated

The alkalies precipitate hydrated peroxide from the solution of this salt, & excess of ammonia redissolves it & forms a triple sulphate of ammonia & copper.

Phosphate of copper may be formed by mixing solution of sulphate of copper with phosphate of soda; it occurs native near Cologne.

Brass is an alloy of copper & zinc; Bell-metal is an alloy of copper & tin, as likewise is bronze in different proportions

The cuprous salts are nearly all soluble in water, & of a blue or green colour. Ammonia produced a compound of a very deep blue, when added in excess to these solutions. Hydrosulphuret of ammonia forms an ~~brown~~ precipitate, & a plate of iron plunged into a liquid salt of copper precipitates metallic copper.

Lecture 35th

Copper Continued.

Both a green & blue carbonate of copper exist native, the former is called Malachite

The carbonate of copper is artificially prepared by adding carbonate of Potapsa to Sulphate of copper, & drying the precipitate; this a green compound insoluble in water consisting of 75 oxide of copper, 20·5 carbonic acid & 0·5 water.

The Hydrocyanate or Prussiate of Copper is formed by adding to a dilute solution of Copper Prussiate of Potapsa, which causes a rich brown precipitate, the Hydrocyanate of Copper.

The alloys of copper are important; with Silver & gold it forms coin & plate of different kinds, the copper increasing the hardness and durability of the coin, with interfering with its colour & ductility. Copper & Zinc form brass: Copper & Tin form bronze & bell-metal.

The Salts of Copper are nearly all soluble in water, & of a blue or green colour. Ammonia produces a deep blue precipitate when added in excess. Hydrosulphuret of Ammonia forms a black precipitate, & a Prussiate of Potapsa a brown one. Iron dipped into a liquid salt of copper precipitates metallic Copper.

of Lead.

The natural compounds of Lead are very numerous; the most important is the Sulphuret, from which the pure metal is chiefly produced.

To obtain lead perfectly pure, it may be dissolved in nitric acid, the solution evaporated to dryness, the dry mass redissolved in water & crystallized; the crystals strongly heated with charcoal afford the metal quite pure. its specific gravity is 11.

There are 3 oxides of Lead. the Protoxide is the basis of all the salts of lead, it may be obtained by heating nitrate of lead to redness in a close vessel. it is of a pale yellow colour, is very soluble in solution of potash & soda, & when in fusion readily dissolves several of the earthy bodies. this oxide is commonly called Massicot, & when mixed with a portion of red oxide, it is called Litharge.

If the Protoxide be exposed to heat & oxygen, it gradually acquires a bright red colour, & is known under the name of Minium or Deutoxide of Lead. this oxide when exposed to nitric acid, is resolved into the two others, & may be regarded as a definite compound of the two.

When lead is heated in Chlorine the gas is absorbed, & Chloride of Lead is produced. it has been found native in Derbyshire & Bavaria

Lay lead heated in Iodine forms Iodide of Lead.

Nitrate of Lead is obtained by dissolving the metal in nitric acid & evaporation.

Sulphuret of Lead may be formed artificially by fusion together it occurs native in great variety & abundance, & is usually called Galena.

+ all the salts of Lead are formed by the protoxide, as
that is the only oxide of the metal soluble in the acids.

+ The Galena or Sulphuret of Lead is the principal source
from which the metal is procured

+ Ferro-cyanate of Potassa produces a white precipitate when added to the soluble salts of Lead.

Hydriodic acid, & hydriodate of Potassa produce a yellow precipitate

Hydrosulphuret of Ammonia produces a brown precipitate

Sulphate of soda is also an excellent test for the presence of Lead, forming a white cloud, very difficultly soluble.

The Salts insoluble in water are dissolved by Soda & Potassa & by Nitric acid, when the metal is rendered manifest by sulphuretted hydrogen

It always contains a little silver, & often in sufficient quantity as to render it worth separating, which is effected by exposing the roasted sulphuret to the action of heat & air in shallow earthern dishes. The lead becomes oxidized, while the silver is left pure, in consequence of its resisting the effects of heat & air. This process is Cupellation.

When Lead is used for analysis it must be pure & reduced from Litharge, that it may contain no silver.

Sulphate of lead is so nearly insoluble that it may be formed by adding dilute sulphuric acid, or an alkaline sulphate, to a solution of nitrate of lead. It is found native in Anglesea & in Scotland.

Hydrosulphuretted oxide of lead is of a deep brown colour, & is produced by adding sulphuretted hydrogen, or hydrosulphuret of ammonia, to any solution of lead; hence these compounds are an excellent test for the presence of lead. †

White Lead of Commerce is the Carbonate, & is produced by adding carbonate of Potash to nitrate of lead.

Lecture 36th.

On Antimony, of no great importance except to the pharmaceutical chemist.

The soluble binary salts of the protoxide of Antimony are precipitated white by water; sulphuretted hydrogen hydrosulphuret of Ammonia give an orange precipitate & a plate of iron or zinc throws down the metal with form of a black powder.

When used in Medicine it is generally in the state of a protoxide, as the peroxide is very inert.

† The salts of Bismuth are precipitated white by water; brownish black by sulphuretted hydrogen, yellowish white by Prussiate of Potasa, & hydriodic acid affords a very characteristic precipitate of a deep brown iodide of Bismuth.

† It is very difficult to obtain perfectly pure Cobalt, as the Arsenic is not easily removed, but obtained with ~~force~~ great closeness. The best way of separating it from Arsenic is to deprive it of the with nitre.

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Lecture 37.

Bismuth.

This metal is found native; combined with oxygen, & arsenic & sulphur.

It may be obtained pure by depositing the bismuth of commerce in nitric acid; water is then added to the nitric solution, while is nitric acid; water is then added to the nitric solution, while is separates oxide of Bismuth. This oxide is then reduced by charcoal.

When exposed to heat & air it oxidizes, forming a fusible white oxide

The salts of this metal are of no great importance

It forms alloys which are remarkable for their fusibility

Cobalt.

The native combinations of Cobalt are the oxide & compounds of the metal with iron, nickel, arsenic & sulphur.

The Muriate of Cobalt is a deliquescent salt of a blue green colour, when a little diluted it becomes pink; the pale pink solution when written with, is scarcely visible, but if gently heated, the writing appears in brilliant green, which soon vanishes as the paper cools, in consequence of the salt absorbing aerial moisture. This solution is called sympathetic ink.

The chief use of Cobalt is as a colouring material for

porcelain. it forms the blue colour
The salts of Cobalt all contain the protoxide: they are decomposed
by ammonia, which if added in excess, redissolves the oxide.

Uranium, Titanium, Cerium, Tellurium
Selenium are but little known & of little importance.

Arsenic.

Arsenic is also of little importance, but as it is a violent
poison, it may be known & hence the best test for it.
a Solution of copper throws down a green precipitate,
Nitrate of silver a yellow one, & it perhaps the best test
Arsenic may be obtained from the white arsenic
of commerce (the Arsenious acid) by heating it with
half its weight of black flux, & subliming it.
There are two oxides of arsenic, the one called the
white arsenic of commerce, the arsenic acid.

The arsenic is generally vended by druggists in
the form of a white powder.
Seldom found in the stomach.
To test the white arsenic by heating with charcoal
a little soap should be added

The last test for the presence of Arsenic is the Marsh-test or Reinsch's test which throws down a precipitate of a peculiar brown color readily dissolved

If a piece of the metal of arsenic be burnt upon Platinum foil, it renders that metal extremely brittle. Steel is otherwise one of the most expensive metals.

+ Sulph. Hydrogen turns it yellow, but no precipitate occurs at first. a little acid renders the effect more evident.

Method of testing for Arsenic +

Dissolve some of the white arsenic in boiling water, separate it into three portions; add a small quantity of Ammonia, by which it is dissolved & formed, the last with Nitrat. of Silver the third throw down a yellow precipitate, mix the second portion with potash not in excess, & test with Sulphate of Copper, a green precipitate falls, very characteristic of Arsenic. To Arsenic. The last the 3rd portion with Sulph. Hydr. which turns it to a yellowish brown, treat the precipitate with evident upon a drop or two of acid being added. if these three appearances take place we may be pretty confident arsenic is present. And if we afterwards test the precipitates with ~~phlogist~~ chlorine & the results of Scheele's tests we may be still more confident.

Nickel is always present in all native irons combined with iron.

Tenacity of texture occasions a very characteristic grey precipitate in dilute solutions of Nickel, in combined solution the precipitate is pale green. The best solvent is Nitro-Muriatic acid.

To separate the iron from nickel, add ammonia in excess, it deposes the nickel forming a blue solution, & an oxide of iron falls.

The blue solution may be distinguished from copper, by the test of Potash, in one case it is brown, in the other pale grey.

Lecture 38

Did not attend this lecture

It was upon Molybdenum, Chrome, Tungsten, Columbium

& Nickel.

Lecture 39.

On Mercury.

The principal ore of this metal is the Sulphuret, or native Cinnabar, from which the mercury is seperated by distillation with quick lime & iron filings.

There are two oxides of Mercury; the black or protoxide may be obtained by long agitation of the metal in contact of oxygen, it is insipid & insoluble in water, & was formerly called Ethiops purse. it consist of Mercury ox $190 + 7.5 = 197.5$.

The red oxide is produced by exposing the metal heated nearly to its boiling point to the action of air, & is sometimes called precipitate per se, it is poisonous & dissolves very sparingly in water: it consists of Mercury ox $190 + 15 = 205$.

The Chloride of Mercury commonly called Calomel consists of one proportion of Mercury & one of Chlorine $190 + 35.5 = 225.5$

The native chloride of mercury or mercurial horn ore has been found native in Germany, France & Spain.

The Bichloride or corrosive Sublimate may be obtained by burning mercury in Chlorine; the gas is absorbed, & a white volatile substance rises, which is the Bichloride.

The most usual mode of preparing calomel consists in reducing the Perchloride (corrosive sublimate) to a Chloride or Calomel. Two parts of corrosive sublimate are triturated with one of Mercury, by which means the mercury attracts part of the chlorine from the corrosive sublimate, & calomel is formed & sublimed by heat.

It consists of Hg Chlorine 190 + 67 = 257.

Mercury & Sodium unite also in two proportions

As the combinations of Mercury are only useful in medicine

I need not enter more fully into their properties.

Lectures 40 & 41

Did not attend.

The Subjects were Gold & Silver.

Silver.

Silver is seldom found pure in nature, but generally contains lead small portions of other metals.

Pure silver may be obtained by dissolving the silver of commerce in pure nitric acid, diluted with an equal measure of water, immersing a plate of clean copper into the solution, which soon occasions a precipitate of metallic silver. collect this upon a filter, wash it with solution of ammonia, then with water, fuse it into a button.

Ag may also be procured by adding to the above solution, a solution of common salt or any compound containing chlorine; collect & dry the precipitate, & fuse it with its weight of subcarbonate of soda, & a button of the metal is obtained.

Oxide of Silver may be obtained by adding lime-water to the solution of Nitrate of Silver, & washing the precipitate. it is a dark olive colour, insoluble in water, & when gently heated, is reduced to the metallic state

The Number representing silver is 102·5, its oxide contains one proportional of oxygen (7·5).

The Chloride of Silver is easily procured by adding a solution of chlorine, of muriatic acid or of common salt, to a solution of Nitrate of Silver, & white precipitate falls, which becomes brown & afterwards black, when moist & exposed to the reducing

Chloride of silver is very soluble in Ammonia, in circumstances by which it is usefully distinguished from some other chlorides, which like it, are white, formed by precipitation. This compound of silver, 108·5 & one of Chlorine 33·5.

The salts of silver are reduced upon charcoal by the blow-pipe. The soluble salts are precipitated by the alkalies, which furnish the insoluble salts are precipitated by the alkalies, which furnish double chloride precipitates; by sulphuretted hydrogen, hydrosulphuret of ammonia nearly black; by infusion of galls, yellow brownish precipitate of tartrate, white. Muriatic acid & the muriates give white precipitates of chloride of silver. Sulphate of iron & sulphate of copper throw down metallic silver.

Gold

Gold occurs in nature in a metallic state, alloyed with a little silver or copper.

It may be obtained pure by dissolving it in nitro-muriatic acid, evaporating to dryness, redissolving the dry mass in distilled water, filtering & adding to it a solution of sulphate of iron, a black powder falls, which after having been washed with dilute NA & distilled water, affords on fusion a button of pure gold.

Oxide of gold may be obtained by adding a solution of potassa to a solution of muriate of gold: it contains 97 gold + 3·5 oxygen.

Mercury & gold combine with great ease, & produce a white amalgam much used in gilding. for this purpose the amalgam is applied to the surface of the silver; the mercury is then driven off by heat, & the gold remains adhering to the silver, and is burnished. This process is called water gilding.

In gilding porcelain gold powder is generally employed obtained from the decomposition of the muriate: this applied

with a hook, & burnished after it has been exposed to the heat of the furnace.

Lecture 42d

Or Platinum.

This metal is found in small grains in South America but generally mixed with other metals.

The pure metal may be obtained by depolosy crude platinum in nitro-muriatic acid, & precipitating by a solution of muriate of ammonia.

It combines with oxygen & chlorine but the exact proportions are not known, Nor its number has not been deduced.

The salts of Platinum have been but little examined.

It alloys have not been applied to any useful purpose

of Silicium.

It has been apound that the earth silica consists of a metallic base, united to oxygen, tho' it has not been actually proved by experiment.

The oxide of Silicium, or Silex or Silicious earth is a very abundant natural product. it exists in rock crystal or flint & nearly pure in flint.

It may be obtained by heating rock crystal to redness, quenching it in water & reducing it to a fine powder.

In its ordinary state it is insoluble in water
It readily unites with the fixed alkalies & forms Salts,
or if the alkali be in excess, a liquid solution of the earth
may be obtained, called liquor of flints, whence it is
precipitated in the state of a gelatinous hydrate by
acids.
The only body which acts energetically upon Silica is
the hydrofluoric acid.
The result of this action is a gaseous compound which has
been called silicated fluoric acid, & is probably a compound
of Silicium & fluorine.
To obtain this gas three parts of fluorspar & one of Silica
finely powdered are gently heated with sulphuric acid in
a retort, & the gas is collected over mercury.
It much resembles muriatic acid, producing white fumes
when in contact with air; & when exposed to water, two
compounds of silica with fluoric acid are formed; the one
acid & dissolved in water; the other containing excess of
earth & insoluble.
The uses of Silica are numerous & important; it forms an
ingredient in pottery & porcelain, & with alkali it forms
glass.

Lecture 43

Did not attend

The subject was Aluminum & the remaining earthy metallic oxides.

Lecture 44th

Of Vegetable Substances.

The circumstances requisite for the healthy germination of a seed are principally the following. viz a due temperature; moisture in due proportion, & a proper access of air.

Hence in all cases of tillage the seeds should be sown so that the air may have access: in light soils this is easily obtained, but in clayey soils, the adhesiveness of the materials is often the cause of their unproductiveness.

The leaves of plants exhale moisture from their under surface, & frequently absorbe carbon from the carbonic acid of the air, & evolve oxygen when exposed to light, & hence tend to renovate & purify the atmosphere. in the night however the leaves exhale carbonic acid.

The sap of plants ascends in the alburnum or newly formed wood & descends in the inner bark.

Tho' the presence of light, air & moisture aided by a due temperature are the principle requisites for the growth of plants, they must also derive nutriment from the soil, which becomes impoverished by their growth, & must be renovated by manures which are of vegetable, animal, or mineral origin; the two former of which are capable of affording two of the essential ingredients of plants, namely Carbon & Hydrogen.

The mere existence however of vegetable matter in a soil is not sufficient to constitute it a manure; it must be reduced to a soluble state, & this is effected by fermentation or putrefaction

The ultimate principles of vegetable substances are few in number; but by being combined in various proportions, they give rise to a series of compounds materially differing from each other, & which may be called their proximate component parts.

Carbon, Hydrogen & Oxygen are the principle ultimate components of vegetables; some afford Nitrogen; in some there are traces of Sulphur, & in their sap or juices we find small proportions of Potasa & of Soda, sometimes of Soda & Magnesia; some also contain silica. common salt is a very frequent ingredient in marine plants; phosphate of Lime is found in oak & some other seeds, & nearly all vegetables yield traces of oxide of iron, & many of oxide of manganese.

When vegetable substances are submitted to destructive distillation, the Carbon, Hydrogen & Oxygen enter into new arrangements, & a variety of products are obtained, differing in quantity & quality; water, oil, acids, carbonic oxide & acid, & carburetted hydrogen are in this way formed, & if the vegetable contain Nitrogen, ammonia may be obtained. a portion of charcoal with the saline & earthy ingredients remain in the retort.

By this subjecting different vegetable substances to analysis, it has been found

First that a vegetable substance is always acid, when the oxygen which it contains is to the hydrogen in a proportion greater than is necessary to form water, or when there is an excess of oxygen

Secondly a vegetable substance is resinous & inflammable, when the oxygen is to the hydrogen in a less proportion than in water, or where there is an excess of Hydrogen

Thirdly a vegetable substance is neither acid nor resinous, but saccharine, mucilaginous &c, where the oxygen & hydrogen, are in the same relative proportion as in water $\left(\overset{Ox}{8 \cdot 5} : \overset{Hy}{1}\right)$ or where there is no excess of either.

The proximate principles of vegetables are chiefly separable by the action of solvents, of which the principle are cold & hot water, alcohol, ether, & a few of the acids

The number of proximate principles which are then capable of being distinguished & separated from each other, is considerable, & must be separately examined.

Lecture 45

Of Gum

Gum is contained in considerable quantities in the sap of many vegetables, & frequently appears as a spontaneous exudation.

It is soluble in water, & may be obtained from it in its original state by evaporation.

It is insoluble in alkohol, which therefore causes a white precipitate in its aqueous solutions.

Sugar.

Sugar may be extracted from the juices of many vegetables. It is chiefly procured from the sugar-cane, the juice of which is expressed & evaporated with a small quantity of lime until it acquires a thick consistency, when it concretes upon cooling, & becomes what is called raw sugar, the remaining liquid portion is molasses or treacle. It is afterwards purified with lime water & blood, to free it from the molasses, & becomes white loaf sugar.

Starch

Starch or fecula may be separated from a variety of vegetable substances, & more particularly from wheat, by diffusing the powdered grain in cold water which becomes white & turbid; the grosser parts are separated by a strainer, & the liquor which passes deposits the starch, which is then dried by a gentle heat.

Stri insoluble in cold water, but readily soluble at a temperature between 160 & 180°. its solution is gelatinous, & by careful evaporation, yields a substance like gum in appearance, which is a compound of starch & water.

The most characteristic property of starch is that of forming a blue compound with iodine.

It appears by a reference to the ultimate elements of starch & sugar, that they differ little in composition, & it is therefore not surprizing that the former is easily convertible into the latter.

The change of starch into sugar is always observed during the germination of seeds, & in the process of Malting.

Gluten

Gluten may be obtained from wheat flour by forming it into a paste & washing it with water; the starch is then washed away, & a tough elastic substance remains, which is gluten.

When allowed to putrify it exhales an offensive odour, & when submitted to destructive distillation, it furnishes ammonia, a circumstance in which it resembles animal products.

The excess of gluten in wheat flour compared with other

grain, renders it peculiarly fit for making bread, for the carbonic acid extricated during fermentation of the paste, is retained in consequence of its adhesiveness, & forms a spongy light loaf.

Wheat grown in this country contains from 18 to 24 per cent of Gluten, the remainder being principally starch.

The wheat of the south of Europe generally contains a larger quantity of Gluten, & is therefore more excellent for the manufacture of macaroni, vermicelli, & other preparations requiring a glutinous paste.

Extractive Matter.

This is a substance contained in the greater number of vegetable, & generally forming the principal ingredient in pharmaceutical preparations.

Tannin.

Tannin or the astringent principle is contained in many vegetables, it may be procured by digesting bruised gall nuts, grape seeds, or oak bark in small quantities of cold water.

It is extremely astringent, & soluble in water & in alkohol.

Its distinctive character is that of affording an insoluble precipitate with animal jelly.

Upon this property the art of tanning depends

Lecture 46th.

Colouring Matter.

The colouring matter of vegetables appears to reside in several of their principles, & is therefore very differently acted on by solvents. Its extraction & transfer to different substances, constitutes the art of dyeing.

Colours are divided into substantive & adjective; the former communicate colour without the intervention of any other substance. the latter require the intervention of some body possessed of a joint attraction for the colouring material & stuff to be dyed. the substance capable of thus fixing the colour, has been called a basis or mordant.

The Mordants most frequently employed are acetate of alumina, Sulphate of iron, & muriate of tin.

The substance to be dyed is first impregnated with the mordant, & then passed thro' the colouring matter, which is thus fixed in the fibre. variety of colours is produced by employing various mordants, & different colouring materials.

Different substances are possessed of very different attractions for colouring matter. animal substances such as wool & silk are generally speaking more easily dyed, & absorb

more colouring matter than cotton, & cotton more than
hemp or flax.

Wax.

This principle exists in many plants, & may be obtained by
bruising & boiling them in water; the wax seperates & concretes
on cooling.

Fixed Oil.

Fixed oil is generally obtained by pressure from certain seeds &
from the olive; a few of them are solid at the ordinary temperature
& are called vegetable butters.
If oil which has been congealed by cold, be pressed between folds
of bibulous paper, & dry concrete fatty matter is obtained, the
liquid matter is absorbed by the paper.
These oils cannot be volatized without decomposition, & when
passed thro' a red hot tube furnish a very large proportion of
carburetted hydrogen gas; & when burned in the wicks of lamps
they suffer a similar decomposition, & water & carbonic acid
are the results.
The alkalies readily combine with fixed oils & form compounds
called Soaps.
Soap forms a milky solution with water. The acids & the greater
number of salts decompose soap, forming in most cases a compound
of difficult solubility; hence hard waters are unfit for washing
in consequence of containing sulphate of lime, hence also

the solution of soap in alcohol is useful as a test for ascertaining the fitness of water for this purpose; which if it becomes very turbid, cannot in general be used for washing.

Volatile Oils.

These oils are generally obtained by distillation from plants which afford them with water.

They pass into vapour at a temperature below boiling water, are very inflammable, & water & carbonic acid are the results of their perfect combustion.

These oils are frequently adulterated with alcohol & fixed oils. the former addition is rendered evident by the addition of water, the latter by the greasy spot which they leave on paper, & which does not evaporate when gently heated.

Camphor.

This substance in many respects resembles the essential oils like them it is volatile, inflammable, soluble in alcohol, & sparingly soluble in water.

Resins.

Resin exudes from many trees. when pure it has scarcely any taste or smell, is insoluble in water, readily soluble in alcohol & becomes readily on the addition of water

a few of the resins derive odour from containing essential oils.

Lecture 49th

Lecture 40th.

On Fermentation.

Fermentation is either vinous or acetous

The principal substance concerned in vinous fermentation is sugar, & no vegetable juice can undergo this process, which does not contain it. in beer the sugar is derived from the malt & in wine, from the juice of the grape.

In the process of fermentation the different substances held in solution begin to act upon each other, carbonic acid escapes in large quantities, the sugar of the liquor is decomposed, its acquires new flavor & becomes intoxicating.

It is found that the only gaseous product is carbonic acid, and consequently that carbon & oxygen are the principles which the saccharine matter loses during fermentation.

The principle upon which the intoxicating properties of fermented liquors depends, is in its purest form called Alcohol.

It is extremely inflammable & the products of its combustion are carbonic acid & water. when the vapor of alcohol is passed thro' a red hot tube it is decomposed, a portion of charcoal is deposited & a large quantity of carburetted hydrogen is evolved.

Alcohol is a powerful solvent of many saline substances; the resins, soaps, extractive matter & tannin, nearly all the volatile oils, & a few of the fixed oils are an copiously dissolved in it.

When alcohol is submitted to distillation with certain acids a peculiar compound is formed called Ether.

When any of the vinous liquors are exposed to the free access of air they undergo a second fermentation terminating in the production of a sour liquid called vinegar.

During this process a portion of the oxygen of the air is converted into carbonic acid; hence unlike vinous fermentations the contact of atmospheric air is necessary, & the most obvious phenomenon is the removal of Carbon from the sour or wine, from which the vinegar is made.

Distilled vinegar consists essentially of the real acid diluted with water. To obtain acetic acid, distilled vinegar may be saturated with some metallic oxide, & the acetate thus obtained, subsequently decomposed.

Acetic acid is composed of

3	Proportionals of Hyd	= 3
4	—— of Carbon	= 22·8
3	—— of Oxygen	= 22·5
		48·3 its Number.

The acetates are mostly very soluble, deliquescent, & difficultly crystallizable; they are decomposed by sulphuric acid

Lecture 49th

On Animal Substances.

The proximate principles of the animal creation consist like those of vegetables, of a few elementary substances, which by combining in various proportions, give rise to their numerous varieties.

Carbon, Hydrogen, Oxygen & Nitrogen, are the principal ultimate elements of animal matter, & phosphorus & sulphur are often contained in it. The presence of nitrogen constitutes the most striking peculiarity of animal, compared with vegetable bodies. By the destructive distillation of animal matter ammonia is formed by the union of the hydrogen & nitrogen.

In putrefaction the animal matter undergoes changes by which it is slowly decomposed into new products. The presence of air tho' not necessary, accelerates it, & those gases which contain no oxygen naturally check & sometimes prevent the process. hence meat may be preserved for a length of time in carbonic acid.

In atmospheric tainted by infectious matter may be purified by the nitrous & muriatic acids, also by chlorine; these act chemically upon the pernicious matter, & resolve it into harmless principles.

Of the Blood.

Blood consists of the Serum & Coagulum. The first contains a portion of Soda, & becomes coagulated at a temperature of 160

in the white of egg, which substance is Albumen.

Albumen always contains soda, is coagulated by heat, acids alcohol. solution of corrosive sublimate also produces a loudness, hence is an useful test of albumen. it is also agulated by voltaic electricity

The coagulum of the blood possess the same chemical properties fined from its colouring matter.

Milk.

The curd of Milk has the leading properties of coagulated Albumen The whey is a transparent fluid which affords a minute quantity aline matter by evaporation, & a considerable portion of sugar milk.

The bile, lymph, & mucus are principally composed of albumen & soda.

The chemical history of the urine is only of importance to the medical practitioner.

Lecture 50th

Did not attend.

It was on Mineray Calculi & the remaining general matter.

Lecture 51st

of the Animal Functions.

of Digestion.

Digestion is a process by which the food of animals is converted into chyle, & which in conjunction with respiration tends to the production of blood. the food duly masticated & blended with a considerable proportion of saliva, undergoes a remarkable change in the stomach, & in a few hours is converted into a pulpy mass called Chyme, & this change is effected by the gastric juice, the chemical properties of which has hitherto baffled the investigators.

The Chyme afterwards becomes blended with bile, & is separated into two portions, one of which is white as milk, & is termed Chyle, the other voided as excrementitious. the chyle is absorbed by the Lacteals & poured into the venous system.

of Respiration.

In the process of Respiration a portion of the Oxygen of the air is converted into Carbonic acid, which varies at

ffrent periods of the day, & probably also in diffrent
dividuals, it appears at its maximum during dijestion;
ith minimum when the stomach is empty.
venous blood being propelled thro' the vessels of the lungs
subjected to the action of air undergoes a considerable change,
acquiring a scarlet red colour.
is change is evidently owing to the action of the air, which
ses places thro' the thin coats of the circulating vessels, & the
this obtained is the removal of the carbon from the venous
ood.
e only chemical diffrence which can be detected between
terial & venous blood, is the existence of a certain excess
carbon in the latter, which it gives off to oxygen, forming
rbonic acid.

Tests for some of the common Metals

Gold.

Gold is only soluble in Aqua regia, that is in a mixture of nitric & muriatic acids.

a plate of Tin or recently made muriate of Tin throw down a purple powder (the Purple of Cassius)

Protosulphate of Iron separates finely divided metallic gold, assuming a brownish green color

Prussiate of Potash which precipitates most of the other metals occasions no precipitate in solutions of Gold.

Silver.

Nitric acid is the only solvent for silver the soluble salts of silver are precipitated of a dark olive color by the alkalies; while by common salt or any of the Muriates, the precipitate is the Chloride of silver, insoluble in Ammonia, which distinguishes it from other precipitates thrown down by this acid.

Sulph. Hydrogen & Hydrosulph. of Ammonia throw down precipitates nearly black.

Chromate of Potash causes a beautiful

arnicon one, Prussiate of Potassa a white one,
a plate of copper throws down metallic silver,
the salts of silver are all reducable upon charcoal
by the blowpipe.

Iron

Iron may exist in solution either in the state
of protoxide or peroxide, usually known in the
former state, but when it does so, it soon becomes
peroxidized when exposed for a short time to
the air. When in a state of protoxide, the caustic
alkalies throw down a white or greenish white
precipitate, which in hydrated protoxide, that
by last contact of the air, becomes green, then
reddish yellow. Prus^{te} of Potassa gives a white
precipitate with the proto-salt, which soon
becomes deep blue on exposure to air, or on the
addition of a few drops of solution of chlorine
or nitric acid. If the iron be (as it generally is)
in a state of peroxide, the caustic alkalies throw
down at once a reddish precipitate, Prussiate
of Potassa a deep blue (Prussiate of Iron) and
tincture of galls a black one. The soluble
salts of Iron give no precipitate with
hydriodic acid.

Copper.

The soluble salts of Copper form with Potash and Soda a blueish precipitate insoluble in excess of alkali. Ammonia gives a blueish white precipitate with an excess of alkali immediately dissolves, forming a very beautiful blue solution.

Prussiate of Potash throws down a peculiar reddish brown precipitate, a plate of iron immersed in the solution is soon covered with a coat of Copper.

Hydrosulphuret of Ammonia throws down a dirty brown precipitate, & hydriodic acid produces an insoluble iodide of an ash grey color.

Zinc

The caustic alkalies produce in a solution of zinc a white precipitate not altered by exposure to air, but are soluble in excess of alkali.

The solutions of zinc are not precipitated by hydriodic acid - Prussiate of Potash and hydrosulphuret of Ammonia produce a yellowish white precipitate provided the solution of zinc be pure. The soluble phosphates, borates, & carbonates also form white precipitates - Zinc metal has only one oxide.

Lead.

The salts of Lead have the hydrosulph for their test, & are known by affording an insoluble black precipitate with Sulph & all the soluble sulphates. Nitr precipitate with Sal & all the soluble salphates. Muriatic acid also throws down a white precipitate not soluble in Ammonia like the Chloride of silver, but soluble in excess of Potash & Soda Prussiate of Potash also throws down a white precipitate - Hydrosulph & of Ammonia & Sulphuretted hydrogen - a blackish one, Chromate of Potash a beautiful yellow one - Hydriodic acid affords a fine yellow precipitate of Iodide of Lead. Zinc precipitates metallic Lead, Steam unmixed with the vapours of Lead All affords a globule of Lead when heated by the blow-pipe.

Tin

Salts of Tin are then distinguished. Prussiate of Potash gives a white precipitate. Hydrosulph & of ammonia a brownish precipitate with the bichloride salts, & a golden yellow or clay orange with the peroxide salts. Salts do not affect the solutions of these salts. Hydriodic

acid affords a fine orange precipitate with solutions of muriate of tin provided there be no excess of acid. Muriate of gold throws down the purple precipitate of Cassius in solutions of protoxide of tin

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Mercury.

The salts of Mercury containing the protoxide give black precipitates with the alkalies, a white with muriatic acid. The salts containing the peroxide furnish with the fixed alkalies reddish yellow precipitates, a white with Ammonia. They are precipitated yellowish by Prof^r of Potash, deep brown by Hydrosulph^t of Ammonia, & a plate of copper separates the mercury in metallic state. Tincture of galls throws down a yellow precipit^e & Chromate of Potash a fine orange colored one. Hydriodic acid gives a yellow precipitate in solutions of the protoxide, but a red precipit^e with the peroxide. The salts of mercury are all volatilized by heat.

Platinum.

The solutions of platinum are distinguished from all other metallic solutions, by affording a yellow precipitate with Muriate of Ammonia

this precipitate is soluble in water, & is reduced by heat to the metallic state. The salts of Platinum are also thrown down of an orange color by salts containing the protoxide of tin. The salts of Platinum afford no precipitate with solutions of Soda or Sulphate of iron, or of Prussiate of Potash, tho' the latter produces a fine green color. Potash & Ammonia & many of their salts occasion yellow precipitates. Sulphu Hydrogen occasions a black precipitate, & infusion of galls a dingy brown one. The solutions of the salts of Platinum are deep or yellowish brown.

Antimony.

Nitric acid acts powerfully on metallic Antimony, & mixed with it in fine powder. The metal like tin becomes peroxidized, but not dissolved. Nitro-muriatic acid readily dissolves this metal, & forms an orange colored solut^n which is decomposed by the addition of water. Iron or zinc immersed in the solution throws down a black powder. The solutions of Antimony afford orange colored precipitates with Sulphu^t of Potash, Muriatic acid, & precipitates

then largely diluted with water.

Arsenic.

Arsenic is usually seen in the shape of a white powder (the arsenious acid) & may be detected in the following manner.

(a) Mix a small portion of it with about 2 parts of black flux; introduce the mixture into a glass tube & gradually heat it red hot in the flame of a spirit lamp. if Arsenic be present a tall colored sublimate will attach itself to the cooler part of the tube, which after having been heated in contact with air, evaporates in a white mass smelling of Garlic.

(b) If the powder itself cannot be discovered, boil the suspected matter in a little distilled water & when the solution has cooled, add a few drops of the solution of Sulphuretted hydrogen, or pass sulphuretted hydrogen thro' it; if arsenic be present, either immediately or after a short time a yellow precipitate will appear.

(c) To the above solution (b) add a few drops of the solution of Subcarb^{te} of Potash, & then a drop or two of solution of Sulphate of copper, an apple-green precipitate will indicate the presence of Arsenic.

(d) Add to the solution (b) a drop of Nitrate of silver & of solution of Ammonia, a yellow precipitate indicate arsenic.

It must be observed in regard to these 4 tests that the first only is unequivocal, that the appearances produced by the others, may originate from the presence of other substances. When however all the appearances ensue, no doubt of the existence of arsenic can be entertained. to obtain however a still greater certainty the several precipitates should be collected, & will, when placed upon red-hot iron, exhale the peculiar smell of Arsenic

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Manganesium

The salts of Manganese containing the protoxide are mostly soluble in water, the solution becomes turbid & brown by exposure to air. They are not precipitated by hydriodic acid, they furnish white precipitates with the alkalis, which soon becomes discolored by by exposure to air. They are precipitated white by Prus^{te} of Potasa & yellow by hydrosulph^{t}

of Ammonia. If the oxicles which the alkalies seperate be dried & mixed with 5 or 6 times their weight of Subct of Potassa, & exposed for a quarter of an hour to a red heat, they afford the substance called mineral Cathelion

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How to test a metallic Solution, when the metals of which it is composed are unknown.

First try the solution with a few drops of muriatic acid, if a white precipitate falls, it contains either oxide of Silver, protoxide of mercury, or protoxide of Lead.

If this precipitate remains insoluble when diluted with a large quantity of water, it must be either oxide of Silver or protoxide of mercury.

If caustic Ammonia produce a black precipitate, or if the solution be very acid, a grey one, not soluble in excess of ammonia, the base is protoxide of mercury.

But if a drop or two of the caustic ammonia produce a brown precipitate, which dissolves in excess of ammonia, or if the solution be acid, no precipitate is produced by ammonia then the base is oxide of silver.

If a yellow precipitate is produced by an excess of a solution of caustic potassa, the base is peroxide of mercury.

If Sulphuric acid or any soluble sulphate produces a white precipitate, the base is protoxide of Lead.

But if muriatic acid does not produce a white precipitate, then test the solution with sulphuretted hydrogen, if no precipitate occurs with this, the base is either protoxide of manganese, oxide of zinc, or protoxide of iron. but if a precipitate appears, the base is either peroxide of iron deutoxide of copper, oxide of gold, or protoxide or peroxide of tin, or protoxide of antimony. And these bases can distinguished by the following experiments.

If a drop or two of ammonia produce a blue color, the base is deutoxide of copper.

If a solution of protosulphate of iron produce a brown precipitate, the base is oxide of gold.

If the precipitate formed by the sulphuretted hydrogen be white, the base is peroxide of iron, but if yellow, the base is peroxide of tin.

If the precipitate produced be orange-red the base is protoxide of antimony.

When Sulph. hydrogen does not throw down a precipitate, the solution must contain either protoxide of manganese oxide of zinc or protoxide of iron.

Then test with caustic ammonia, if a white precipitate be produced, soluble in excess of the alkali, the base is oxide of zinc.

If tested with Carbonate of potassa, the precipitate be first white, then green, & finally brownish-red or the reverse, the base is protoxide of iron.